

# **Climate Change: Potential Effects on Demands for US Military Humanitarian Assistance and Disaster Response**

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A handwritten signature in black ink, reading "Ronald Filadelfo". The signature is written in a cursive, slightly stylized font. The first name "Ronald" is written in a larger, more prominent script, and "Filadelfo" follows in a similar but slightly smaller script. The signature is centered horizontally within the block.

Ronald Filadelfo  
Director, Environment and Energy Team  
Resource Analysis Division

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# Contents

<b>Summary</b> . . . . .	1
How will climate change affect future disaster response operations? . . . . .	2
How will climate change affect the security environment for future operations? . . . . .	3
How do we decide to deploy forces? . . . . .	3
What capabilities do US military forces bring? . . . . .	4
Findings. . . . .	6
<b>Introduction</b> . . . . .	7
Objectives. . . . .	7
Types of emergency events . . . . .	7
Methodology: climate and its interaction with military response . . . . .	8
This paper . . . . .	10
<b>Effects of climate change on frequency, intensity, and distribution of disasters</b> . . . . .	13
Climate change effects on rapid-onset disasters . . . . .	14
Effect of climate change on rapid-onset disasters . . . . .	15
Tropical cyclones . . . . .	15
Extra-tropical cyclones and windstorms . . . . .	18
Fire. . . . .	19
Flooding and mudslides . . . . .	21
Geologic hazards . . . . .	22
Abrupt or catastrophic climate-change events . . . . .	23
Changes in ocean circulation . . . . .	24
Abrupt sea level rise due to ice sheet collapse. . . . .	25
Time scales for climate change effects . . . . .	26
A framework for examining climate change effects on humanitarian emergencies and rapid-onset disasters . . . . .	28
Evolving missions . . . . .	28
Emerging missions . . . . .	30

Revolutionary missions . . . . .	30
Humanitarian emergencies and slow onset disasters . . . . .	31
<b>Changes in the security environment . . . . .</b>	<b>35</b>
Predicting stability . . . . .	36
Areas most vulnerable to climate change . . . . .	38
Implications for response operations . . . . .	42
Complex disaster response (CDR) operations . . . . .	44
<b>What does the military do in disaster response? . . . . .</b>	<b>47</b>
US military foreign disaster response 1970-2008 . . . . .	47
Decision-making process for foreign disaster response . . . . .	48
International framework . . . . .	48
USG framework . . . . .	49
Implications of the decision frameworks . . . . .	51
US military responses to natural disasters. . . . .	52
Character of US responses . . . . .	53
Summary of characterizations . . . . .	68
Implications . . . . .	69
<b>The military's unique role in disaster response . . . . .</b>	<b>71</b>
Command, control and communications. . . . .	72
Theater lift . . . . .	73
Tactical transport. . . . .	73
Security operations. . . . .	75
Military planning and risk management capabilities. . . . .	77
Planning. . . . .	77
Games, exercises, and analysis . . . . .	78
<b>Conclusions . . . . .</b>	<b>81</b>
Evolving missions. . . . .	81
New missions . . . . .	83
Emerging missions . . . . .	83
Revolutionary missions . . . . .	84
Recommendations . . . . .	84
<b>References . . . . .</b>	<b>87</b>
<b>List of figures . . . . .</b>	<b>99</b>
<b>List of tables . . . . .</b>	<b>101</b>

## Summary

How will climate change affect military humanitarian and disaster response operations?

Answering this question requires answering a number of other, related, questions. How will climate change affect the frequency, type, and nature of disasters and humanitarian emergencies? How will pressures from climate change affect social and economic factors that determine the security situation at the scene of the response? What types of disasters do US military forces respond to today, and how do they compare with those types of disaster most affected by climate change? Why does the US commit military forces to a disaster response operation? And what unique capabilities do they bring when they arrive?

To answer these questions, we examined the climate literature in order to determine projected changes in frequency, intensity, and location of large-scale events. We also examined the type, location, and nature of US military commitments, by using extensive databases of past US response operations. Finally, we examined the possible ways in which climate change might decrease stability in already-marginal countries, by using existing measures of country stability and projections of future climate impacts on fragile nations.

All of these sources suggested that there was a great degree of uncertainty about how future disaster response and humanitarian assistance operations will change. Climate model predictions lack the resolution to identify the precise increase in storm landfall, intensity, or frequency of occurrence just 20 or 30 years into the future. Instead, we found general principles such as “storms will increase in intensity but not number.” Models of nation-state stability are even more problematic: they identify key attributes of stability but have a limited ability to project as far into the future as is needed for an analysis of climate change effects.

Because of this uncertainty, we used the available data to derive some general principles that will most likely shape military and civilian policy in the future. These principles can be used to guide broader policy efforts, and identify areas where additional detail or research is needed.

## How will climate change affect future disaster response operations?

We found that the effects of climate change on future events, in terms of military response, could be characterized in one of three ways:

- *Evolutionary.* The military responds to the same events that it currently responds to, but they grow or evolve. Some current missions will evolve as the climate changes, causing certain disasters to become more intense or more numerous in the future. For example, hurricanes and typhoons are expected to increase in intensity as average global temperatures rise. These changes may simply mean “the same, but more” when considering what capabilities may be needed in the future.
- *Emergent.* The military responds to events that it currently responds to only infrequently. Some missions that are rarely done now may become more frequent, and some that are local may grow in scale. For example, fire outside of the United States is not currently the subject of large-scale US military response operations. The recent fires in Australia were fought with local and non-governmental resources [1–2], but that may change due to changes in fire patterns, intensity, or frequency.
- *Revolutionary.* The military responds to completely new missions that come about because of climate change. These missions are not currently considered part of the international response framework, but may arise as a result of climate change. For example, any mission in which the military becomes involved in order to affect carbon emissions, and thus climate change, would be a revolutionary mission.

While resource requirements for existing missions can be extrapolated by scaling up based on increased numbers of events, new missions make it difficult to use past behavior and resource commitments in predicting how future forces may be used.

## **How will climate change affect the security environment for future operations?**

The presence of armed conflict may make disaster response or humanitarian assistance operations more complex, requiring military or other forces to stabilize the situation before aid can be delivered. In the past, this has been the case for several complex humanitarian assistance operations—for example, those in Somalia and Haiti. In many cases, such as in Somalia or Sudan, a long history of instability and violence is the underlying cause of the humanitarian crisis.

While it is not possible to predict whether climate change will create new security environments, it is likely that the effects of climate change will increase the stress on already marginal economies and societies. Changing agricultural, economic, water, or migration patterns may disrupt national economies and tip otherwise marginally stable countries into instability or violence [3–4]. This, combined with the predicted increase in extreme weather events, could lead to a larger number of humanitarian and disaster response operations occurring in unstable environments. This, in turn, may increase demand for US military forces to conduct security or stabilization missions.

## **How do we decide to deploy forces?**

In order to understand future demand for US military forces, it is important to understand how the United States government decides to deploy military forces in support of humanitarian and disaster response missions. To do this we examined a database of past deployments and found that military forces deploy for a wide range of emergency response missions [5]. Most such missions are short-duration air operations with one or two aircraft. Longer and more complex missions are a small fraction of the overall number of responses to emergencies. Many of these longer, more-complex missions respond to storms of higher Saffir-Simpson categories, and deploy to Africa. Higher-category storms tend to draw military forces because of the extent of the damage and the destruction caused to traditional infra-

structure (such as roads, harbors, and airports) that would support civilian response.

The recent deployment of US military forces to Haiti is an example of a response to an overwhelming emergency that occurred with no notice and resulted in damage to infrastructure, such as ports and airfields that would normally be used for aid delivery.

If the current trend of responding to higher Saffir-Simpson category storms continues, an increase in storm intensity due to climate change may also result in more military deployments. Likewise, if climate change causes social and economic pressures that increase instability in Africa, military humanitarian assistance missions may become longer and more complex.

Historical deployment data show that employment of military forces in support of disaster response is a policy and political decision. We see no evidence of a trend in why or when military forces are deployed. The reasons for deployment appear to be determined by each administration independently. The decisions do not seem to be directly related to the political party of the administration. This lack of a clear trend makes it extremely difficult to project future deployments, as changes in outlook or administration appear to have a great influence on whether deployments occur.

## **What capabilities do US military forces bring?**

While US military forces bring a wide range of capabilities to humanitarian or disaster response operations, they bring relatively few *unique* capabilities. For example, medical capabilities are also available in some non-governmental and governmental agencies; therefore, military medical assets represent only an incremental addition. Likewise, the World Food Programme and others have developed the ability to move large quantities of supplies by air and sea, making the military's logistics capability less unique than it was 10 or 20 years ago. If aid and non-governmental groups continue to develop robust response capabilities, US military communications and logistics may also become incremental additions to civilian capabilities in the future.

Because some missions may emerge that are not currently common, additional skills or capabilities may be needed. The primary example is fire fighting, which is not a common mission now but may be in the future. This may require skills and capabilities currently residing in Guard units, which commonly are called on to fight domestic wild-fires, to be included in or incorporated into active units. Likewise, the military's ability to conduct large-scale planning and wargaming of "what if" scenarios may need to be expanded to include climate-related threats as well as conventional ones.

The joint planning process—along with the military's experience with games, real-world events, and analyses—may provide a tool and a process for better understanding the range of risks involved in climate change. As we do not fully understand how decision-makers will approach future climate-induced requirements, gaming provides a tool for better understanding these decisions. Likewise, current real-world relief and aid events provide insight into what our current capabilities are able to achieve in the field. Analyses provide a quantitative capability to examine a range of scenarios and possibilities. This process could be adapted to understanding future climate impacts, with policy decisions and real-world data informing an analysis of potential requirements.

Security operations remain the one area in which the military brings *unique* capabilities to HA/DR operations. While the UN and NGOs can provide communications, theater lift, and tactical movement of aid supplies, they are limited in the scope of security operations they can conduct. In particular, private or non-governmental security forces have not typically carried out active suppression of threats; they have performed mostly defensive operations. Since military forces are uniquely qualified to carry out security operations, the demand for military deployments may increase.

## Findings

Climate change is likely to cause an increase in demand for military forces in both disaster response and humanitarian assistance operations. An examination of the unique capabilities brought by military forces suggests that the demand may be for security, with other func-

tions, such as lift or mobility, augmenting existing governmental or non-governmental capabilities.

As the climate changes, there may be underlying, and unpredictable, changes in the nature of the mission for military forces. Changes in intensity of weather-related disasters, combined with a decrease in stability in many countries, might result in disaster response operations occurring in a region with security threats. Likewise, if climate change itself emerges as a motivation for intervention, the “where, when, and why” of US military force intervention may be substantially different from today.

All of these forces combine to suggest that climate change may introduce significant “non-linearities” in the system of response, aid, security, and stability, making simple projections of future requirements extremely difficult.

# Introduction

The United States military conducts disaster response or humanitarian operations around the globe each year. Some are as simple as sending a small team of doctors to provide medical care to underserved populations. Others are as large and complex as the response to the 2005 tsunami or the 2010 Haiti earthquake. In this section we discuss what we mean by “emergency event,” and describe the objectives and methodology of this study.

## Objectives

This paper is part of a larger study of the effects of climate change on the whole of government response to humanitarian emergencies and disasters both domestic and foreign. The larger work, sponsored by the Rockefeller Foundation, examines the implications of climate change for US domestic disaster response operations, and the effect on the US overseas aid delivery and disaster response systems [6–7].

Here we focus exclusively on the US military component of any response, attempting to define and examine the effect of a changing climate on military missions, and resource requirements.

## Types of emergency events

There are many ways to characterize or organize emergency events.<sup>1</sup> In general, they can be put into broad categories depending on how much advance notice they provide, what responses are required, and what kind of security situation is present.

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1. We also use the term “disaster” as shorthand for “emergency event”; however, the concept of what is and is not a disaster is a subjective assessment.

The organizations that respond, the type of tasks needed, and the resilience and adaptation strategies used will differ, depending on how much warning time is available. “Rapid-onset” disasters, such as flash floods, mudslides, storms, and fire, give little notice. “Slow-onset” disasters, such as drought, flooding, or economic collapse, give time to identify the disaster, and to respond.

We can also characterize events according to the type of response needed. “Disaster response” refers to response operations occurring over a short period of time, most likely because a rapid-onset disaster has occurred. “Humanitarian emergencies/responses” occur over a long period of time and generally involve providing economic and development assistance as well as emergency relief. Humanitarian emergencies tend to be associated with slow-onset disasters, and disaster responses tend to be associated with rapid-onset disasters.

A “complex humanitarian emergency” is an acute humanitarian emergency in the midst of an ongoing security threat or conflict. The 2006 tsunami response is an example of a typical disaster response, while ongoing events in Somalia and Sudan are examples of complex humanitarian emergencies. There are very few humanitarian emergencies that are unrelated to some form of conflict. For a detailed discussion of the various categories of events, see [8-12].

## **Methodology: climate and its interaction with military response**

In this paper we are interested in how military response to rapid-onset disasters and humanitarian emergencies will change in the projected warmer climate. Because we are interested in humanitarian and disaster response operations involving military forces, there are some things we do *not* cover in this paper. For example, we do not discuss routine military engagement operations. Instead, we focus on operations that respond to particular natural or man-made events. While we are concerned with “slow-onset” disasters such as desertification, mass migration, and changes in agricultural production, we are interested in them only as far as they change the stability or security situation within a country. In themselves, they don’t automatically create

an “emergency” that requires commitment of military forces. In many cases, the country will adapt to the change and not need help from international relief or response organizations.

It is also important to point out that in this paper we do not try to assess the current projections for climate change. In writing the paper, we started with the baseline IPCC estimates as given assumptions. When, as we frequently found, the IPCC reports did not address projections in sufficient detail, we searched elsewhere within the scientific literature. Our focus in this paper is on how political and military requirements will change if the projected changes in climate occur.

There are several ways in which climate change may affect disaster and humanitarian response operations:

- It may change the *nature* of the disaster. Disasters such as windstorms may become more frequent, or they may be more devastating, or both.
- It may change the *type* of disasters we respond to. For some disasters, such as fire, military response is generally not seen as cost-effective; however, if climate change expands the scale or scope of such disasters, the need for military response may increase.
- It may change the political *rationale* for responding. If climate change is seen as a threat to national security, anything that tends to increase warming may be seen as a security threat. Response to such threats would include actions to reduce or control carbon emissions, such as fire control.
- It may change the *security context*. Climate change may affect global security [3–4]. For example, drought and desertification may cause population migrations, resulting in civil or state-on-state conflict. With an increase in the number of conflicts, more responding organizations will face collateral or hostile opposition.

To understand the effect that these changes will have on disaster and humanitarian response, we need to learn how the US military

responds to humanitarian emergency and disaster response events today [9]. To do this, we will use a comprehensive historical database of past missions [5]. We also need to learn what capabilities the US military brings to humanitarian and disaster response operations. Again, we can use experience as a tool for understanding present, and future, capabilities.

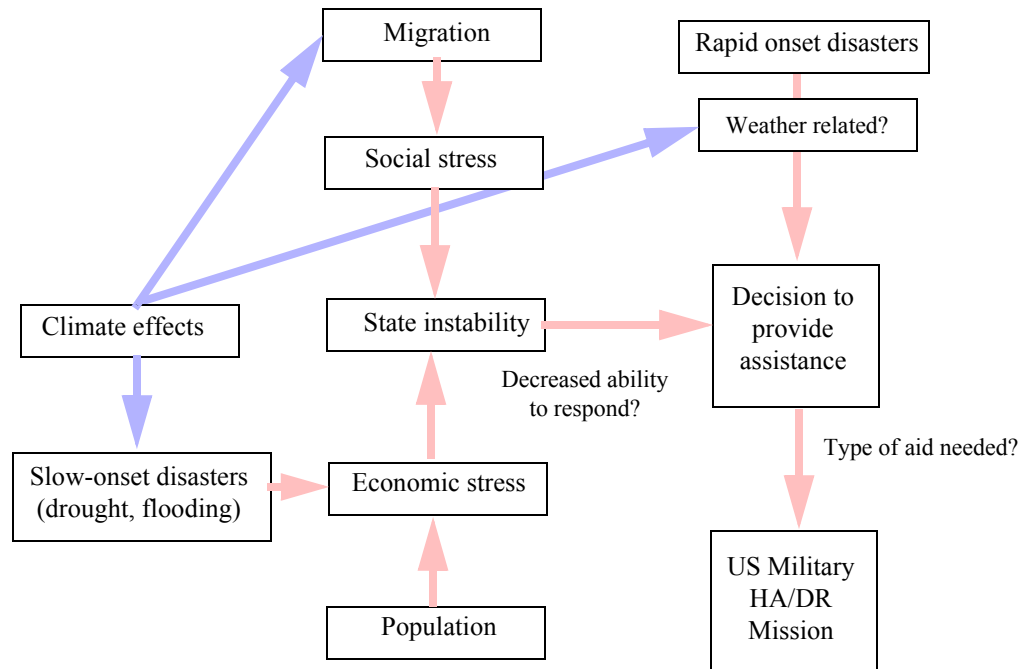
How will demand for US military capabilities change in the future, as climate changes? We explore this by focusing on two primary drivers: the changing climate environment, and the changing security environment. How these two changing landscapes interact will determine military, and more importantly, political and institutional, response requirements.

Figure 1 shows our model for how climate change relates to the US government's decision on whether to commit support to intervention. As shown in the figure, climate and other effects, such as population growth, can produce both economic and social stress, which can put pressure on already marginal states. If rapid-onset disasters also occur, the desire to prevent additional instability—along with the decrease in response capability caused by the already disrupted economy and social infrastructure—may lead US policymakers to decide to commit forces.

## This paper

In the following sections we will discuss how climate change will affect rapid-onset disasters and humanitarian emergencies. We will show that climate change may affect not only the intensity and frequency of disasters, but also the types of disasters we can expect. Then we will consider changes in the security situation that result from climate change. We can then compare these effects with operations the US military has conducted in the past, in terms of both scale and type. Finally, we will discuss some unique roles that the US military can play in disaster response, particularly operations conducted in the context of climate change. By synthesizing all of these factors we can identify fundamental changes that will occur over the next century—changes that will significantly affect the political calculus of when and where US forces are committed.

Figure 1. Relationship between climate effects and US HA/DR response



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## Effects of climate change on frequency, intensity, and distribution of disasters

Global effects of anthropogenic carbon emissions on global climate have been well documented [13–14]. What is less certain is how the global climate system will react on the smaller spatial and temporal scales.

For example, climate models may predict additional northern boreal forest fires. However, it is difficult to extract from the literature the mean increase in the size of fires, their location, and their rate of increase in frequency. Those numbers become important when planning how many airframes to produce over the next 30 years in order to have aircraft to fight those fires.

This problem of prediction is compounded when considering humanitarian assistance. Unlike rapid-onset disasters, slow-onset humanitarian disasters typically result from a combination of social, economic, political, and environmental causes. The fact that water becomes scarce somewhere, or that a population needs to relocate due to a rise in sea level, doesn't necessarily mean that a humanitarian crisis will develop—much less a crisis that US policy-makers will take notice.

This combination of slow onset, conflict, and need for commitment of US political will for an intervention, makes it even more difficult to foresee where and when US forces might be committed.

In this section we focus on rapid-onset disaster response. In particular, we examine the effects of climate change on disaster frequency, scale, and timing. We develop a framework for understanding both rapid-onset disasters and humanitarian emergencies. We also examine the relationships between humanitarian emergencies, particularly complex ones, and rapid-onset disasters.

In later sections we consider the more complex set of factors that result in the need for humanitarian response missions. Those cases involve not only the stress induced by the natural environment, but also the internal and external political, social, and economic environments.

## Climate change effects on rapid-onset disasters

In this section we attempt to answer the question: What are the projected effects of global climate change on the frequency and intensity of rapid-onset events? This is a “scenario and storyline” approach [15], where we develop a set of possible bounds for how the future world might evolve, and use them to explore impacts on military forces. Because we need predictive data, we are willing to take published results and incorporate them into our storyline.

We will focus on weather-related disasters, as these are the ones that will most likely be affected by climate change. However, weather-related events are only a fraction of all the rapid-onset disasters that the US military responds to. It has also responded to non-weather events, such as the 2005 Pakistan earthquake [16] and the 2004 tsunami [17]. While, as we will discuss, geologic disasters may also be affected by climate change, here we assume that these responses form a baseline or background for our analysis of weather-related changes in type, frequency, and duration of missions.

Weather-related, rapid-onset disasters expected to be affected by climate change include tropical and extra-tropical storms, fires, ice storms, dust storms, flash floods, and emerging infectious diseases.

Slow-onset disasters, such as flooding, drought, famine, and desertification, are not listed here. Because they take place over long periods, other organizations and aid groups can provide effective humanitarian aid (unless there is a security threat).

Note that the US military responds to only a small fraction of disasters worldwide in any given year—fewer than the US government provides aid to, and far fewer than the United Nations declares as disasters [9].

Thus, small-scale disasters, such as mudslides, seldom receive US military response, unless there are other, political, factors.

## **Effect of climate change on rapid-onset disasters**

In order to estimate future requirements for disaster response we need to understand how climate change will affect disasters. It could change their type, scope, or timing. Particular disaster events could take on new traits—for example, disease outbreaks might change from vector-borne to wind-borne due to desertification—or they could change in scope, becoming larger or more intense. The most likely change is intensification of tropical cyclones as a result of warming. Disasters could also change in timing, becoming longer in duration, more sudden in onset, or more or less frequent.

In the following sections, we examine each category of disaster and analyze what current climate-change literature says about possible trends.

### **Tropical cyclones**

Of all the rapid-onset disasters that may be affected by climate change, tropical cyclones are the most discussed, and the most likely to be affected by warming temperatures.

While climatologists have tried to define the relationship between increased temperatures and cyclone activity, no definitive model predicts this relationship. Researchers believe that cyclone intensity will increase but the number of storms making landfall will stay more or less the same. Thus, more storms at the higher end of the Saffir-Simpson scale will make landfall.

#### **Current research**

The number of major hurricanes can vary greatly across decades. Hurricane activity in the Atlantic basin (Atlantic, Caribbean, and Gulf of Mexico) is affected by sea surface temperature, wind shear, and the El Niño Southern oscillation phenomenon, among other effects. North Atlantic hurricanes were quiescent during the 1900s through 1920, then had a relatively high level of activity from the 1920s

through the 1960s. Activity subsided from 1970 through 1987 and had a resurgence in 1988 and 1989. This dissipated from 1991 through 1994, due in part to a long-lasting El Niño event. Activity returned to above-average levels from 1995 through 2008 (except for 1997) [18–19]. Major cyclone activity is highly variable, fluctuating in intensity, frequency, and landfall location. In [18], the authors suggest that most of the hurricane activity seen in these cycles is due to multi-decade variability. Sea surface temperature (SST) contributes to tropical storm variability, but it is not sufficient to explain all of the changes seen.

Because we are entering into an active interdecadal period, it is likely that there will be above-average hurricane activity in the Atlantic for the next 10 to 40 years regardless of climate change [18]. In particular, the number of Caribbean Sea and Atlantic hurricanes will increase. Only minor differences in hurricane activity will be seen in the Gulf of Mexico, but more hurricanes are projected to strike the East Coast of the United States.

Thus, without climate change, the interdecadal cycle in itself may affect hurricane frequency as well as the number of disaster events that military forces must respond to. Climate effects will occur alongside interdecadal changes in natural storm frequency and, as we discuss next, primarily affect the intensity of the storms.

In examining climate simulations with sufficient detail to capture tropical storm formation, Webster et al. [19] find no consistency in the effects of climate change on hurricane frequency. They also find no consistent relationship between tropical storm activity and SST trends in either ocean basin, and they find no significant trend relating SST to tropical cyclone frequency and duration for any of the basins or globally. There was an increase of activity in the North Atlantic after 1995, but there is no basis to suggest that it was due to warming, given a lack of similar trends in other regions.

However, when using those same simulations to examine intensity, Webster et al. find that category 4/5 tropical storms<sup>2</sup> almost double

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2. Category 4/5 on the Saffir-Simpson scale.

in number in all of the ocean basins. While the number of 4/5 storms increases, the intensity of these 4/5 storms themselves does not change. Table 1 in their paper [19] shows an increased frequency for major hurricanes during a major hurricane up-cycle. They found that category 4/5 storms increased by 57% in frequency from the first half of the 1970–2004 period to the second half [19]. They cannot determine whether this change was caused by changing SST or was the result of a longer-cycle phenomenon. In fact there is strong evidence to suggest that it was an interdecadal cycle [20].

For a summary of the current findings on cyclone variability and potential increase in intensity, see [21].

### **How will tropical cyclones change?**

Change in the number of response operations will depend on whether, and how much, damage from typhoons and hurricanes increases. Increased damage will occur through greater frequency, intensity, or tendency to landfall. Current models and consensus predict that intensity will increase, while frequency will remain the same or fall. As historical data show, the tendency to landfall determines the extent of damage. In China, the greatest number of landfalls occurred during cold and dry periods. This suggests that landfall probability has to be considered as important as frequency or intensity. Unfortunately, landfall probability is difficult to predict [22].

In general, increased water vapor in the atmosphere reduces large-scale tropical circulation, depressing the number of typhoons even in a higher-SST scenario. At the same time, the increase in amount of water vapor leads to more intense storms when the conditions are right for them to form. Between the 20th and 21<sup>st</sup> centuries there was a 12% decrease in number in storms, but there was an increase, from 12 to 17, in cyclones with maximum winds > 112 mph (50 m/s). Overall maximum wind speed increased from 181 to 195 (81 to 87 m/s). This seems to apply to all regions [23–24].

An even more pronounced trend, unrelated to warming, is the interdecadal cycle in hurricane numbers [18]. There were 105 category 4/5 storms in the North Pacific from 1960 to 1974, then 75 from 1975 to 1989 and 115 from 1990 to 2004. This is a 40–50% increase in fre-

quency during periods of frequent activity. The effect of SST, noted in the previous paragraph, causes an additional 40% increase in category 4/5 cyclones.

The projected increase in intensity due to climate change has the potential to change interdecadal cycle minimums to cycle maximums, and cause an additional increase in cycle maximums. Because US military forces are most likely to be committed to respond to extreme weather events where local response capacity has been damaged or overwhelmed, an increase in category 4/5 hurricanes could significantly increase the total number of events for which a military response might be appropriate.

In general, it appears that tropical cyclone activity is affected by both a natural cyclic variability and a warming-induced variability. The primary variability related to SST involves the strength of the storms, rather than the likelihood of landfall or the frequency of storms. While exact predictions are not available, it is likely that category 4/5 hurricanes will increase in frequency in the Atlantic and North Pacific.

## **Extra-tropical cyclones and windstorms**

Extra-tropical cyclones occur in the mid-latitudes (30–60 degrees) and consist of low-pressure areas that travel along frontal boundaries. There is a wide variety of such low-pressure structures, and some can produce heavy rainfalls and high (> 74 mph) winds. In Europe, these events are called “windstorms.” In 1987 a windstorm in the UK had winds of 137 mph, and caused approximately \$2.3 billion in damage [25].

Such storms mainly cause damage in the United States and Europe. In the United States, they are associated with ice, hail, and snowstorms, while in Europe they produce both precipitation and wind damage. In the Pacific, these storms may be related to tropical cyclones, but in general they are distinct events.

The same mechanisms that increase the intensity of tropical cyclones (i.e., higher SST and greater humidity) may reduce the intensity of extra-tropical cyclones. Extra-tropical cyclones are driven by

tropospheric temperature gradients, which are greatest in winter. A warming would reduce those gradients, reducing the intensity of the cyclones [26].

Reduction in the overall number of storms is consistent with models of extra-tropical cyclone activity in a warmer world [26]. These studies predict a slight decrease in the number of cyclones, but no changes in wind speed. What will change is the total precipitation: we can expect an 11% increase along storm tracks for the IPCC A1B scenario<sup>3</sup> over the next century, and the regional effects may be more severe than the overall global average [26]. Some areas of high rainfall may even see a 30–50% increase in local precipitation [26, 28].

At the same time, reduced snow cover in Europe could allow storms to penetrate farther inland, due to a blocking effect of the snow pack [29].

These results suggest that, while storm frequency and intensity may decrease, precipitation-induced flooding may occur, and storm effects may be felt farther inland in Europe than they are today.

## Fire

Fires occur worldwide, particularly in Canada, the United States, Brazil, Argentina, Russia, Sub-Saharan Africa, China, Indonesia, and Australia [30]. Fires produce primary effects on ecosystems and populations, as well as secondary effects from downwind aerosol and particulate release. They can increase the probability of flash floods and landslides [31]. Some effects may be multiplicative: fires and burning are associated with increased precipitation due to heat and aerosol release, which, in turn, may produce flash flooding [32].

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3. The IPCC Special Report on Emissions Scenarios (SRES) defines four “storylines” or sets of scenarios: A1, A2, B1, and B2 [27]. The A1 set describes a future world of rapid economic growth, a global population that peaks mid-century and then declines, and rapid introduction of new technologies. The scenarios are defined according to how the energy system is affected by technology change, with the A1B scenario having a balance across all sources of energy.

In the past, fire fighting has not been an important military mission outside the United States, though it is a major domestic mission for the National Guard. Currently fires threaten population and property over limited areas when compared to tropical cyclones or floods. However, recent fires in Australia demonstrate that large-scale fires could threaten developed areas [2, 33].

Changes in fire patterns due to climate change are predicted for northern boreal forests, including those of Canada and California [34]. This is because new weather patterns may result in drying of existing or excess fuel, causing more frequent or more intense fires [35]. Other factors affected by climate change, such as lightning strikes, may change the ways in which fires start.

In addition to population and ecosystem impacts, any increase in fire intensity or duration would increase atmospheric greenhouse gas concentrations. Currently, biomass burning produces up to 40% of gross carbon dioxide and 38% of tropospheric ozone [36]. Additional burning in ecosystems such as boreal forests would further increase this carbon load. This, combined with the population and ecosystem factors, may increase pressure on the military to respond to fires in the future.

The relationship between fire hazard and climate has been studied extensively for boreal forests in Canada, Europe, and Russia. In these locations, burning results from natural events (lightning strikes) as well as human sources. Often, in remote areas, fires are allowed to burn as part of a natural regenerative process. Burning in the tropics tends to be mainly caused by humans [37–39].

For boreal forests, General Circulation Model (GCM) studies have suggested that lightning-caused fires will increase by 44%, and the associated area burned by 80%, by the end of the 21<sup>st</sup> century. More recent studies [36] suggest that the burned area will increase by 74–118%. Other studies suggest that, in Ontario, human-caused ignitions will increase 18% by 2050, and 50% by 2100 [36]. Fires are regional, and the effects of climate change may be very localized: some areas may have more fires, while other areas have fewer fires [37–43]. Some models predict that the fire threat will increase in central and eastern North America, but will be lower in the northeast [43–44].

Because the frequency and intensity of fires depend on local conditions, it is difficult to establish an overall value for changes in fire conditions due to warming. However, several factors unique to fire may become important in determining whether military forces will deploy in response to fire outbreaks:

- The relationship between fire and carbon emissions may make the fires more of a threat to global security, increasing the perceived importance of response.
- Large-scale, fast-moving fires may have significant effects on populations, as seen recently in the American west, Australia, and Indonesia. Direct threats to life and property from fire, as well as indirect threats from smoke and particulates, may increase the overall probability of response.
- Secondary effects of fire, such as flash flooding, may compound the threat to populations and property. Thus, it may be the combined effect of several changing variables that increases the priority of fire response.

## **Flooding and mudslides**

Flooding is perhaps the most significant outcome from any overall warming, due to the potential for sea level rise. Only flash floods can be considered truly rapid-onset events. However, flooding and sea level rise may increase the overall damage and destructiveness of storms, due to wider vulnerable areas. Floods may also result in displaced populations and loss of coastal infrastructure, which can further increase economic pressures on already marginal states.

Sea level changes vary over both time and location [45]. Ensemble estimates for all the scenarios predict a rise of 0.18 to 0.59 meters above 1990 levels by the end of this century [46]. In the IPCC A1B scenario, sea level is estimated to increase by 0.21 to 0.48 meter above 1990 levels, but could vary within +/- 0.15 meter of the average. In contrast, the A1FI estimate goes as high as 0.59 meter [27]. But this can vary by location. For example, in England the sea level rise may be as great as 0.8 meter over the next 100 years [45–48].

River flooding may be the result of a projected increase in the frequency of intense precipitation events [48]. The projection is for longer periods of dryness, punctuated by periods of more intense rainfall. The likelihood of very wet winters is projected to increase over central and northern Europe due to the increase in intense precipitation during storm events (see the discussion of extra-tropical cyclones above). Mid-latitude regions will have more rain and snowfall, producing more runoff. Similar results are seen for Asian monsoons, with more intense summertime precipitation resulting in a greater risk of flooding.

There will be a net increase in overall precipitation worldwide over the course of the next 100 years, and much of the additional rain will fall in mid-latitude regions, including Canada, northern Europe, and Russia. Flooding—combined with other factors, such as fire or storm surges—may become more severe, particularly in the northern latitudes. Even in areas of lower mean rainfall, episodic floods may occur more frequently, as rainfall rates may increase during storms.

## Geologic hazards

In addition to climate effects on meteorological events and sea level rise, some work has suggested that earthquake and volcanic activity can be affected by changes in climate [49–53]. Mason and Pyle [50] found that over the past 300 years volcanic eruptions have followed a seasonal trend, with seasonal fluctuations amounting to 18–50% of the average eruption rate. They attributed this to deformation that occurs in the Earth's surface as a result of seasonal movements of water. Christiansen et al. found seasonal variation in seismicity in the western United States, with peaks occurring in the winter and spring. They suggested that snow unloading and groundwater recharge could generate stresses that may contribute to seasonality [52].

These effects are hypothesized to involve change in shape or composition of the crust due to changes in seasonal sea level, glaciation, ground water, or even astronomical or tidal forces [52–53]. Volcanic activity, in turn, can affect the climate due to gas and particulate emissions [50].

An increase of 18 to 50% in seismic and volcanic activity is approximately the same level of change that is projected to occur in tropical storm activity. This would result in an overall increase in the range of 20-50% in almost all of the major rapid-onset hazards that international relief organizations respond to. As was the case with tropical storms, it will be necessary to better determine the magnitude of the events that will be affected in order to determine whether US military forces will become involved. A large increase in smaller events may result in little or no response, even from the broader US government and international communities. Kennett and Thunell suggest a linkage between crustal deformation and an increase in Quaternary explosive volcanism [53]. If, along with tropical storms, there is a concurrent increase in major events, changes in geological activity may have a significant effect on response requirements.

## **Abrupt or catastrophic climate-change events**

Recently there has been considerable discussion of “Black Swan” events: events of low probability with the potential for high impact in terms of resources or consequences [54]. These “low-probability, high-impact” events are particularly troublesome for organizational planning and accounting, as it is difficult to justify resource expenditure on contingencies that will very likely not happen. As a result, it can be difficult to understand what can, and cannot, be done to decrease the overall impact of the events once they do occur.

Military forces are inherently trained to expect and anticipate Black Swan events. Victory in warfare is often predicated on delivering an unexpected blow that renders the enemy unable to respond. Similarly, in response to natural disasters, the military tends to engage when unusual or atypical events occur—events that traditional civilian disaster response capabilities are not organized or equipped to address.

Because it would be foolish to devote large amounts of resources to threats that may never materialize, Black Swan events are mainly dealt with through planning and rehearsing. While the particular events that are planned and rehearsed for may never take place, the experience of planning for any anomalous, large-scale, event will create a

system and personnel better able to adapt and respond to what actually does occur.

Planning is a key capability that the US military brings to the table. Examples include responses to Hurricane Katrina, threatened chemical or biological attacks, and the 2005 tsunami. Such events are particularly suited to capabilities and skills that the US military already possesses.

Black Swan scenarios associated with climate change are referred to as “abrupt climate change” or “catastrophic climate change.” These events are triggered by crossing some threshold, and occur more rapidly than the events that caused them[27]. They are also characterized by self-regulation: after the tipping point is reached, internal system dynamics take over and the system assumes a new stable state.

The historical and geological record lists a variety of these events, including the “Little Ice Age” that occurred from AD 1550 to 1850 [54], the “Medieval Warm Period” from AD 1100 to 1200 [55], and other abrupt warming and cooling events [58]. On geologic time scales, there have been periods where precipitation patterns changed dramatically over a period of 1 to 3 years [57]. Because these are “low probability” events, they are best-documented ones in the paleontology literature.

The goal of this section is not predictive; rather it is to examine potential scenarios that could occur, and identify those of significance to military forces.

## **Changes in ocean circulation**

The Atlantic Meridional Overturning Circulation (MOC) is a flow that takes fresh cold water down the Atlantic basin and moves saline warm water northward along the surface. Should the MOC change, there could be significant climatic effects in the North Atlantic. These effects have been seen in paleoclimate studies, and at least one warming-cooling cycle, the Dansgaard-Oeschger oscillation, occurs rapidly and repeatedly [56]. Other rapid climatic change events may also involve changes in ocean circulation or chemistry. An example is the

Younger Dryas and 8.2ka<sup>4</sup> abrupt cooling that occurred during the warming associated with the end of the last glaciation [57–58].

These events can occur over short periods of time—for example, the Dansgaard-Oeschger event is characterized by an 8–10 degree C<sup>5</sup> warming in Greenland over the course of several decades [57–58]. Other events, such as Heinrich events, are characterized by cold periods lasting hundreds to thousands of years, followed by warming on decadal scales. A possible trigger mechanism for these events is changes in ocean chemistry due to melting ice sheets. There is ongoing debate about how well existing models simulate the interplay between ocean chemistry, ocean circulation, and abrupt climate change [58].

It is uncertain whether the MOC will change under warming [58], and cases can be made for both change and little change.

At their most rapid, these cycles occur over decades. There will be ample warning that a disaster or humanitarian emergency might result, and military forces will have plenty of time to plan. Instead, what may take military forces by surprise is the concern that could emerge over such contingencies. If models or other data suggest that current forecasts are wrong, and that abrupt oceanic circulation changes are possible, military forces may be pressed to prepare plans or options on much shorter time scales than the effects themselves would permit.

## **Abrupt sea level rise due to ice sheet collapse**

A collapse of the West Antarctic Ice Sheet (WAIS) could occur due to increasing water temperatures, and meltwater accelerating ice flow. A complete collapse would cause a global sea level rise of approximately 5 meters [27]. The collapse of either the WAIS or Greenland ice sheets is not predicted by current modeling. However the current

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4. 8.2ka = 8,200 years.

5. This equates to 14 to 18 degrees F, or roughly the mean annual temperature difference between Virginia and Florida.

models do not include all of the relevant processes and there is no consensus about what processes might emerge [27].

Uncertainty over ice sheet collapse sets up future scenarios in which either the Greenland sheets or WAIS are more likely to collapse or discharge into the oceans than currently assessed. In this scenario, social pressure for rapid response to flooding, saltwater intrusion, and other consequences of sea level rise could affect military forces.

## Time scales for climate change effects

When considering policy and programmatic changes for US military forces, one question is “Within what time scale must the system react?” Changes that occur rapidly will be “come as you are,” while longer-scale effects will allow time for the current system to adjust. Most of the systems considered here are highly variable across geography, and the predictions are at too low a resolution for us to determine a precise timeline for how they will evolve; still, it may be useful to determine whether their evolution will be predictable, or abrupt and unpredictable.

In general, we can expect the following time scales for changes in the systems considered here:

- **Tropical cyclone activity.** The interdecadal cycle appears to operate on a Low-Change-High cycle, with 10–40 years of relatively low-level activity, 10 years of change, and 10–20 years of high-level activity.<sup>6</sup> Superimposed on this, we have the overall global warming trend, which suggests a 4% change in wind speed per 1-degree change in SST. Various model projections suggest that global sea surface temperature will increase 0–0.5 degrees by 2030, 0.5–1.5 degrees C by 2065, and 1.0–2.5 degrees C by 2099 [27]. This suggests that any increase in overall hurricane strength will be slow, with a 0.5–1.0 degree temperature increase per 30-year period, corresponding to a 2–4%

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6. Based on an analysis of 1970 through present-day data in [16] and [17].

increase in wind speed (which should, in turn, track with increases in tropical storm intensity).

- **Extra-tropical windstorms.** Because changes in extra-tropical cyclones appear to be related to changes in SST or humidity, they should increase at the same rate as tropical cyclones, following an approximately linear model of sea surface temperature.
- **Fire.** Because fire is a complex system involving fuel, humidity, weather conditions, and human activity, it may be difficult to predict rate of change in fire patterns. Human ignitions will scale with population and land use, with more fires predicted as population grows. Fire may, however, present abrupt and non-linear changes—not because of any natural phenomena, but rather because preventing fires would decrease overall global carbon emissions. If fire fighting becomes a policy issue, fire operations may rise in priority, particularly in northern boreal forests.
- **Flooding and mudslides.** As with tropical and extra-tropical cyclones, precipitation events appear to be linked to sea surface temperature and oceanic circulation. Thus, flooding will most likely scale with SST.
- **Volcanoes and earthquakes.** As earthquake frequency may change seasonally due to snow and groundwater fluctuations [52], changes in frequency of volcanic and earthquake activity may be rapid once glacial unloading occurs. The rate of increase of these events would therefore depend less on the time scale for their reaction and more on the rate of deglaciation, sea level change, and changes in precipitation.
- **Abrupt climate change.** Large-scale, abrupt changes associated with warming appear to occur on decadal or longer scales. While this provides considerable time for any military action (except for the longest programmatic decisions) social consequences of recognizing the potential impacts of abrupt climate change may result in demands over a much shorter time span than the actual events themselves would permit.

## A framework for examining climate change effects on humanitarian emergencies and rapid-onset disasters

Changes in rapid-onset disasters will produce changes in response missions. We divide these changing missions into three categories, according to *how* they will change, and what effect these changes might have on US decisions to respond:

- **Evolutionary.** Missions we currently do, but will do more often in the future.
- **Emergent.** Missions we currently do not perform frequently, but may in the future, due to increased intensity or risk from the disaster.
- **Revolutionary.** Missions that are not even possible or contemplated in a world without climate change, such as a response to a climate change cause itself.

Humanitarian emergencies are related to rapid-onset disasters in two ways:

- Rapid-onset disasters can have destabilizing effects on already fragile populations.<sup>7</sup>
- The local security situation will affect the ability of outsiders to respond to the disaster. For example, after the recent typhoon in Burma, the local “security situation”—in this case, the government’s attitude— kept international responders at bay.

### Evolving missions

Climate change can increase the frequency or intensity of rapid-onset disasters. This will likely result in the US military doing the same missions it does today, but more frequently.

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7. Rapid-onset disasters can interact with underlying economic or social fragility in many ways, from direct disruption, to the effect of responders’ aid on local economic activity [10].

Tropical cyclones and windstorms are primary examples. Tropical cyclones will increase in intensity, but not necessarily in the overall number of storms that make landfall. For tropical cyclones, the steady increase in numbers of higher-category storms due to climate change effects will be superimposed on the interdecadal cycle. For extra-tropical windstorms, the range and scope of the effects may change, as dominant weather patterns over Europe and North America change. Some areas that currently do not receive high winds and heavy precipitation may now feel those effects. Unlike tropical cyclones, these effects are additive in both space and time.

- For **tropical cyclones**, the literature indicates there will be something on the order of a 50% increase or decrease in frequency in category 4/5 storms due to interdecadal cycle [18]. Superimposed on this will be a 40% increase in category 4/5 storms due to SST effects [21, 23]. As we will discuss later, higher-category storms represent a large component of US military disaster response operations. This portends a substantial increase in the demand for these missions.
- **Extra-tropical cyclones** may see some small (10%) increase in overall precipitation through the next century, but most of the larger regional effects will occur in oceanic or polar regions [26–28]. Changes in European snow pack may cause current storm tracks and intensities to move farther inland. These effects may produce more regional flooding, or snow and ice events over Europe or North America.
- **Flooding** will become more common in the future despite projected decreases in overall precipitation. With less frequent, but more intense, precipitation, the magnitude of flash floods and river flooding will increase. In addition, burning may increase the rate of runoff, increasing flood intensity. Sea level rise will augment the effects of storm surges. Increased precipitation will concentrate in mid-latitude regions, including North America, Europe, and Russia [45, 48].
- **Volcanoes and earthquakes.** Changes in environmental variables such as snow or liquid loading can produce a 18–50% increase in activity. During the last deglaciation, volcanic activ-

ity increased globally by two to six times above background levels [49–53].

Military response to tropical cyclones, earthquakes, and volcanoes are common disaster response missions today. Any increase in the numbers or intensity of those events will most likely result in a proportionate potential for US military response.

## Emerging missions

Climate change may affect our responses to rapid-onset disasters by changing the *type* of disasters that occur.

Fire is our primary example. Fires may become an increasingly important object of overseas disaster response due to increases in their intensity and duration [59], but also because of their potential to produce additional atmospheric carbon, which would, in turn, accelerate warming. These events are of two types:

- Large-scale fires that threaten populations and property, such as those seen recently in Indonesia [59] and Australia
- General fires that represent a threat of increased carbon emission.

Currently fire response in northern boreal forest fires is limited. Even for events as large and significant as the recent Australian wildfires, it is not a common US military mission. However, in the future, the location, character, and scale of forest fires may change as weather patterns change. Some areas may have more, and larger, fires. If these areas are politically or militarily sensitive, forces may be deployed to respond. At the same time, fire is a significant source of carbon loading into the atmosphere, and thus may represent a threat of increased global warming unless controlled.

## Revolutionary missions

Climate change will alter the relative priorities and geographical distribution pattern of military response missions. Governments may change their political or policy priorities, choosing to respond to different disasters, and taking different actions.

There are several possible ways to interpret this change in missions:

- The nature of rapid-onset disaster response may change because the security and humanitarian situation on the ground becomes worse due to climate change.
- The political will to conduct disaster response missions may increase as more frequent rapid-onset disasters erode the underlying security situation in some countries.
- Climate change *itself* emerges as a motive for military intervention. As warming becomes a daily reality for many of the world's populations, the causes of warming may in turn become a security issue for many nations, the US included. If countries begin to see climate change as a significant threat to national security, rapid-onset disasters that increase carbon emissions may become national security issues. Forest fires are an example, but additional missions may evolve to include technological disasters, such as chemical plant explosions.

## **Humanitarian emergencies and slow onset disasters**

Climate change is predicted [59–60] to increase the stress on economies and social structures due to lower agricultural output, displacement from coastlines, loss of access to water sources, disease outbreaks, and habitat change (desertification). As these pressures increase, they will interact with political and social systems to increase the likelihood of conflict. This marginal increase in conflict above baseline levels, while impossible to predict precisely [12], will expand the potential scope of rapid-onset disasters in already destabilized or marginal states.

It is important to understand that most of the effects from long-term climate changes will occur “on the margins” of economic, social, and political activity. For example, global irrigation requirements may increase between 5 and 20% by 2070–2080 according to some studies [61], and cereal yield will vary between a 20% increase and a 20% decrease<sup>8</sup> depending on the mean local temperature change and the latitude [61]. Grassland and livestock productivity will follow a similar trend, increasing in productivity with mild warming (0–2° C) and

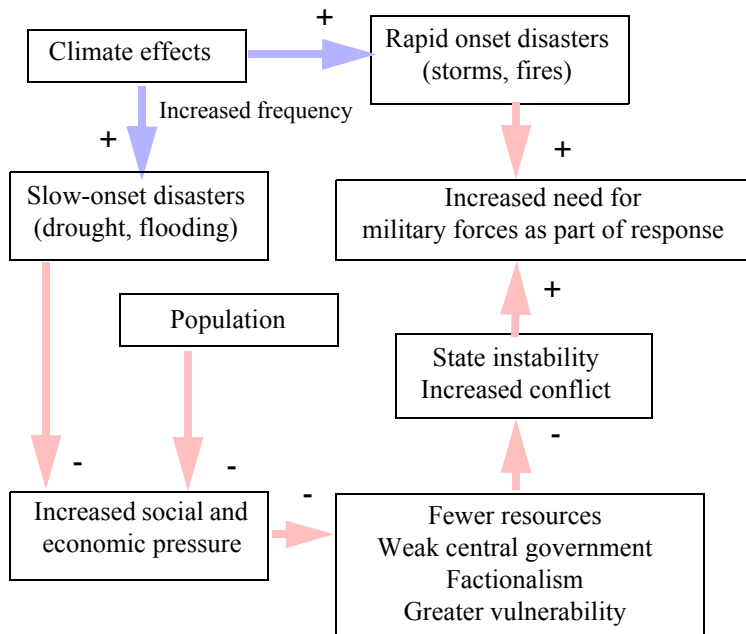
decreasing with higher temperatures [61]. These incremental pressures may not, in themselves, drive resilient economies and states into failure, but they are another stress that will challenge marginal states.

In general, the goal of US foreign policy has been to seek stability around the world.<sup>9</sup> Instability is believed to increase the likelihood that disruptive or irregular security challenges will emerge—for example, unstable states are more likely to provide safe havens for terrorists [62–63]. If rapid-onset disasters increase instability in marginal or unstable states, there will be political pressure on the military to intervene and provide assistance. If, in turn, the number of unstable or marginally stable countries increases due to climate change, the number of occasions for military intervention will also increase. Figure 2 depicts this cycle of increased frequency, increased pressure, and ultimately increased numbers of responses.

Inevitably, the increasing frequency of natural disasters, combined with increasing stress on social institutions, will increase both the demand for responses, and the number of responses. In the next sections, we will explore the factors that make up this equation: social and economic vulnerability, and the decision-making process for US response. In the final section we will discuss the capabilities that the US military brings to a disaster response.

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8. Some latitudes would see a small increase in response to a smaller temperature increase, but almost all latitudes would see a decrease in response to a higher temperature increase.
  9. Whether US actions actually achieve this goal is difficult to determine; however, what is important for this paper is that stability in the international system is a long-term goal of the United States, and that many of its humanitarian and other actions are designed with this goal in mind.

Figure 2. How climate pressures can result in increased responses



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## Changes in the security environment

It is a widespread belief that climate change will change the security environment in many regions by increasing state instability and conflict [3–4]. As we discussed in previous sections, the marginal pressure from climate change may affect countries that are less developed or less resilient. Countries that are already unstable may become more unstable due to dwindling resources and increased conflict. States on the verge of instability may be “tipped over” into instability by climate-induced stresses. Increased demands for resources may stretch providers of aid and development assistance, decreasing the overall amount of help available at the very time when help is needed most.

To understand the future environment for humanitarian assistance missions, and how that environment will be shaped by climate change, we must understand the dynamics between disaster, resources, stability, security, and vulnerability. The future environment cannot be fully understood through a static calculation of the number of displaced people or the magnitude of disasters. Rather, it is a set of interconnected problems of development, social, economic, and political stability, and the external environmental forces that might push previously stable states into instability.

We must first understand the stability of response environments around the world in order to determine what policy decisions might be made now in preparation for future response operations. A degraded security environment—due to small- or large-scale conflict—will shape the US military response. Large-scale events, such as hurricanes or typhoons, or poorly managed responses might tip a country where adaptation is ongoing into an unstable state where adaptation is less possible. The need to stabilize these countries, and to decrease violence so that adaptation may proceed, may drive the US military into simultaneous disaster relief and security missions.

In this chapter we will use an existing measure of stability to identify less stable states. We will then compare that stability index with projected climate change vulnerabilities, emphasizing areas particularly vulnerable to climate effects. In the next section these two maps can be compared to the locations where we have intervened in the past, to help us understand how the elements of any assessment of climate change effects on military intervention come together.

## Predicting stability

It is possible to predict instability<sup>10</sup> in the short term [66]. Then, the further out the time horizon, the more variables become involved in the prediction and the more difficult it becomes. Even for the long term, however, we can identify the key variables that determine stability, and investigate how those might interact with climate stresses. Current research into predicting stability shows that:

- When a regime is a complete autocracy or a complete democracy, the risk of instability is lowest.
- When a regime is a partial autocracy or partial democracy, the risk of instability rises.
- Within partial democracies, countries that experience political factionalism (promoting particular agendas benefiting a specific group instead of the common good) along with a high level of open competition for power are most likely to become unstable [66–67].<sup>11</sup>

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10. In its narrow sense, we use the word “stability” in the same way that the US military uses it in its definition of stability operations: “to maintain or reestablish a safe and secure environment, provide essential governmental services, emergency infrastructure reconstruction, and humanitarian relief” [64]. This is a basal interpretation of the term to essentially mean that the rule of law is operative and violence is not pervasive. We expand this to also include the general rule of law, functioning economy, stable social environment, and participation in the international community. The general concept of political stability is complex and subject to many different definitions [65].

11. For a discussion of general trends, see [68].

- Instability can quickly develop in countries where factionalism in present—this is especially true when a country is in transition from autocracy to a partial democracy.

These factors will shape the need for humanitarian or disaster response, and the way that the response is perceived. Scarcity of resources, in particular, interacts with factionalism in unpredictable ways. Where there is already a bias toward promoting one group over another, scarcity of land, agricultural resources, or water may serve to sharpen that bias. This, in turn, can increase conflict.

In addition to these predictive factors, a survey of unstable states indicates that these states share certain characteristics linked to continued instability:

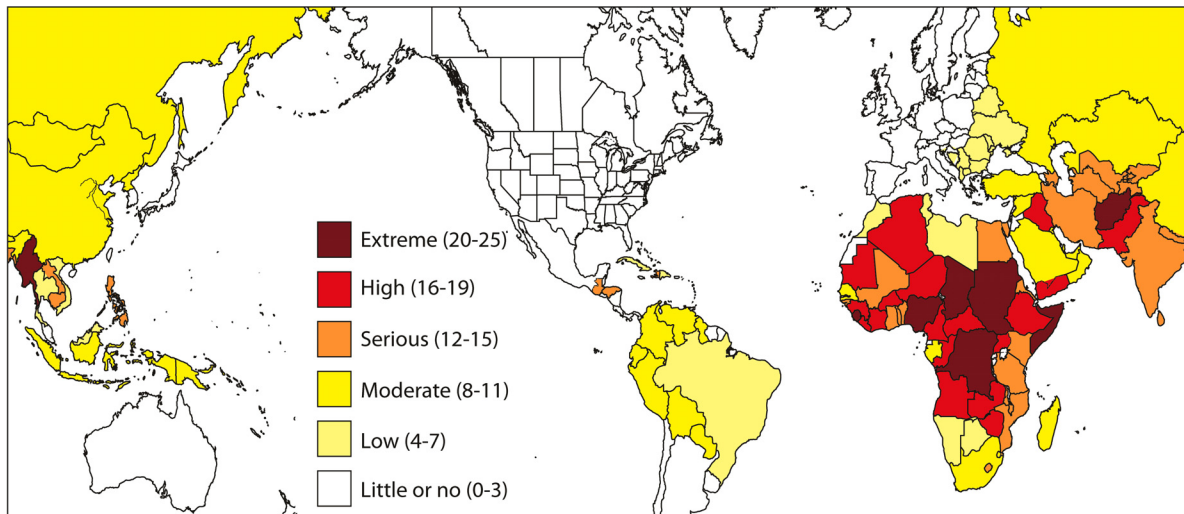
- Long and varied history of regional conflict
- Culture of corruption
- Government's inability to serve or protect people
- Limited infrastructure
- Failing or limited economy.

These characteristics, combined with the instability factors discussed above, provide a rough guide for estimating the future response environment in any given country. However, instability is not just a local phenomenon; it also occurs in a regional and international context. Evaluation of the response environment must consider regional stability, including adjacent countries and cross-border issues. Figure 2 illustrated this process of increasing pressure on economic and social institutions, their interaction with limited resources, and other factors contributing to instability.

Several indices have been developed to evaluate stability in different countries [69]. Figure 3 shows the State Fragility Index developed for USAID by the IRIS Center at the University of Maryland. The index is a matrix sum of political, economic, social-demographic, and security factors measured according to the state qualities of effectiveness and legitimacy. Details on the methodology are described in [69–70]. While these calculations are somewhat arbitrary, they provide a way to

characterize stability that has been used over long-term data sets (since 1995).

Figure 3. State Fragility Index: 2008 [70]



## Areas most vulnerable to climate change

Climate change vulnerability is a complex variable that is hard to calculate definitively. The IPCC consensus report does not contain country-by-country assessments of vulnerability. It is also difficult to predict the effects of a changing climate. Effects will manifest over many years, during which countries may adapt and change in terms of other variables that contribute to resilience—such as consumption shifts, demographic changes, and changes in urbanization patterns and rates. Reaction to climate change can also take variable and unpredictable courses, from unexpected adaptation (e.g., Colombia’s conversion to coal-fired power plants in response to climate-induced loss of hydropower) to complex reinforcing mechanisms that may affect stability (e.g., population shifts due to migration, which may decrease diversity in a population, thus decrease factionalism).

The International Development Association (IDA) used IPCC projections of climate change along with a measure of overall risk to establish a list of countries that might be most affected by climate change. The risk measures were total number of people affected by a given climate impact combined with the number affected per million dollars of Gross Domestic Product (GDP). Assessment focused on drought, flood, sea level change, and agricultural loss. It omitted water and human health. Water was omitted because of its variability in distribution and effects. Human health was omitted for three reasons: it varies widely at the sub-national level; it is a slow-onset disaster, and therefore is not necessarily a driver of instability; and the humanitarian response involves public health and environmental preventative medicine capabilities that are not a primary focus for the US military (though it has some capabilities in both areas for own force protection) [71].

The IDA list of countries most affected by drought, flood, storm, and agricultural losses is shown in figure 4 and table 1.

Figure 4. Countries most at risk from climate change (as assessed by IDA [71])

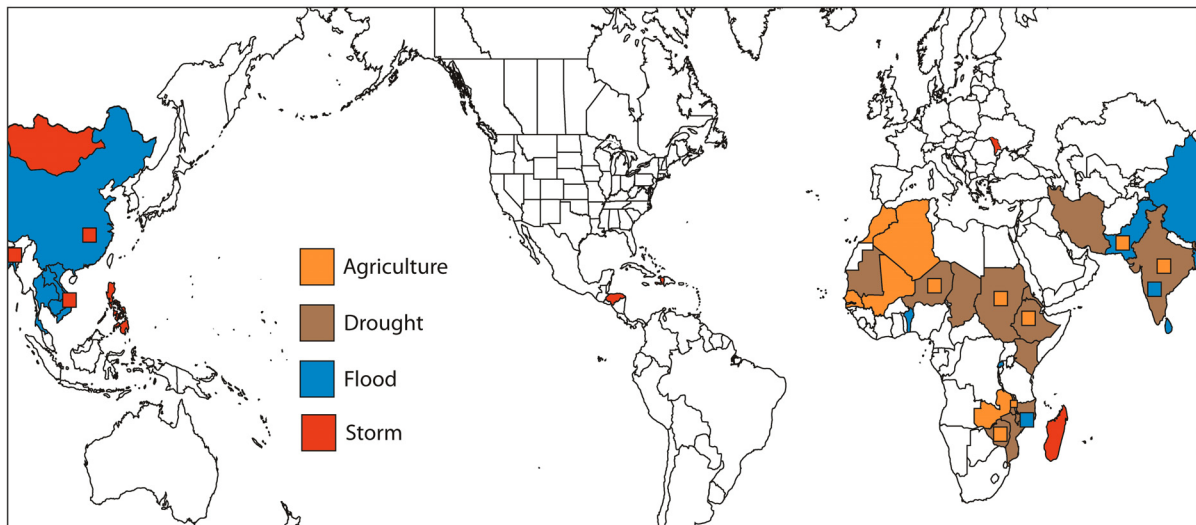


Table 1. Countries Most Affected by Drought, Flood and Storm [71]

Drought	Flood	Storm	Agriculture
Malawi	Bangladesh	Philippines	Sudan
Ethiopia	China	Bangladesh	Senegal
Zimbabwe	India	Madagascar	Zimbabwe
India	Cambodia	Vietnam	Mali
Mozambique	Mozambique	Moldova	Zambia
Niger	Laos	Mongolia	Morocco
Mauritania	Pakistan	Haiti	Niger
Eritrea	Sri Lanka	Samoa	India
Sudan	Thailand	Tonga	Malawi
Chad	Vietnam	China	Algeria
Kenya	Benin	Honduras	Ethiopia
Iran	Rwanda	Fiji	Pakistan

Conservative estimates predict that extreme weather caused by climate change could reduce world Gross Domestic Product (GDP) by as much as 1% by 2050 and by 5% each year thereafter [72]. While individual effects (e.g., increases in populations, in numbers of rapid-onset disasters, and in stress from long-term changes in coastlines and rainfall), may be manageable, the combination of effects may be significantly more challenging.

In many developing countries that depend on natural resources (such as Ethiopia and Tanzania) the growth or contraction of Gross Domestic Product varies almost directly with rainfall variability. This is because their economies are driven by rain-fed agriculture, which accounts for about 70% of all fresh water consumption [73]. Agricultural losses from changes in rainfall patterns would place pressure on the overall economy, and thereby decrease the resilience of these countries. When additional effects from storms or fires were added to slow-onset climate effects, the pressure could be sufficient to tip these countries over into instability.

In the case of Ethiopia, the World Bank in its Country Assistance Strategy showed a close link between rainfall and economic

productivity. Interruptions in planting due to a late early-season rainfall, or crop failure due to lack of rain after planting, result in less acreage under cultivation and lower overall GDP. A graph of rainfall variation from the mean value along with GDP growth for Ethiopia showed that changes in GDP tracked closely with positive or negative variations in rainfall [74].

Another factor that may increase pressure on economies in the future is population growth. World population grows by almost 80 million per year (with an expected 3 billion total increase in the number of people by 2050). Of these, 90% will be born in developing countries, where water-related stress is already a challenge [75]. Sub-Saharan Africa and South Asia will account for half of the world's population by 2100, and in these regions urbanization is driving many people to cities that are vulnerable to disaster due to lack of protective infrastructure in coastal areas subject to flooding and storms.

Figure 5 shows projected change in population by 2080<sup>12</sup> (displayed as the ratio of the projected 2080 population to the 2000 population) [73, 76]. As the figure indicates, countries projected to have the largest population increases are in the equatorial belt that corresponds to the areas most susceptible to climate-induced drought, storms, and agricultural declines (though population growth was included as a factor in determining vulnerability in figure 4).

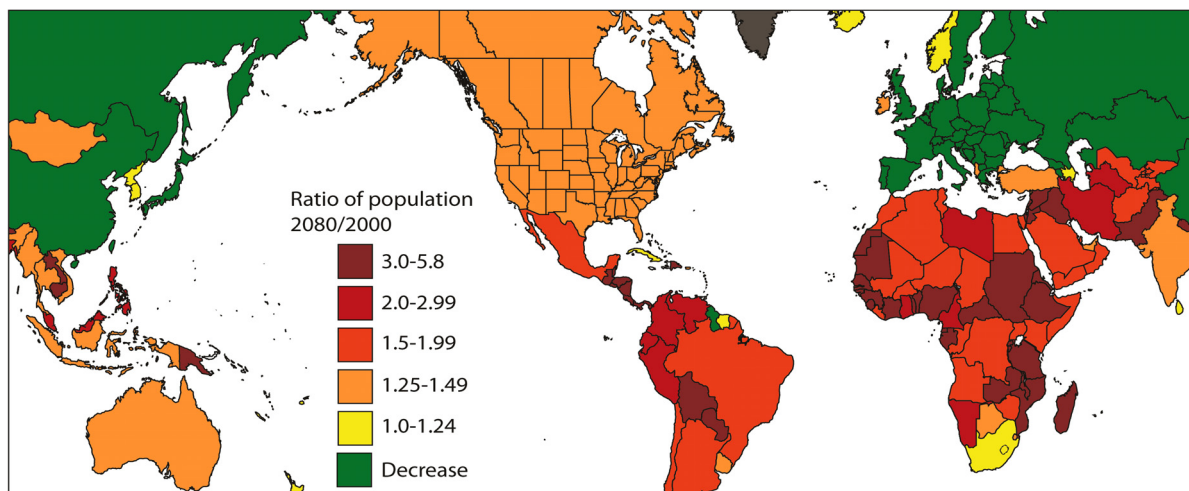
Together figures 3, 4, and 5 suggest that the least stable regions are also most vulnerable to stresses from climate change and population increase. While we cannot predict which countries will be most challenged, there are regions where instability, climate-related stresses (particularly on agriculture or other areas of the economy), and population growth converge. These are:

- Central and Eastern Africa (Somalia, Sudan, Chad, Democratic Republic of the Congo, Rwanda, Mozambique, Benin, etc.)
- The Middle East (Iraq, Iran, etc.)

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12. Calculating population change is dependent on assumptions about changes in fertility, mortality, and migration rates.

Figure 5. Projected 2080 population increase [76].



- South Central Asia (Afghanistan, Pakistan, India, Sri Lanka, etc.)
- Portions of the Far East (Burma/Myanmar, Philippines, etc.)
- Central America (Guatemala, Honduras)

This conclusion is similar to that of the IPCC 2007 report [77], which identified Africa as one of the most vulnerable continents. East and South-East Asia are expected to experience a 20–30% decrease in crop yield along with coastal flooding and loss of freshwater access.

## Implications for response operations

The factors that may lead to instability include:

- Political factionalism in the context of a government in political flux
- A culture of corruption, inability of government to serve and/or protect people, limited infrastructure
- Failing and/or limited economy
- A history of regional conflict.

Climate change events, whether long-term or rapid-onset disasters, can affect economies and infrastructure and thus increase the overall likelihood that formerly stable countries will become unstable. While climate change is only one of many factors that can have these effects, its universal nature, and its tendency to affect populations and economies, make it more powerful than other factors, such as technological or social change.

For military assistance—as opposed to intervention from other government agencies, such as United States Agency for International Development (USAID) and its Office of Foreign Disaster Assistance (OFDA)—the key determining variable will be the security environment. While we can speculate about climate change’s impact on stability, the critical question is whether climate change will increase *conflict*, as well as instability.

Conflict can dominate decision-making about intervention and aid. In recent years, many slow-onset disasters have had a security component. Examples of these “complex humanitarian emergencies” (CHEs) include NATO’s operations in Bosnia, Somalia, Haiti, Rwanda, and most recently, Sudan. CHEs are characterized by the need for emergency humanitarian aid, as well as security threats that prevent or deter aid delivery. Security threats come from factionalism or inter-state conflict, whose origins are complex and often unrelated to underlying economic or governance issues. The impact of climate change on these threats is uncertain, making it difficult to predicting their frequency or nature.

Rapid-onset disasters, on the other hand, often have no security component. Due to their sudden nature, the extensive loss of life they cause, and the short duration of the relief process, opponents may set aside differences until relief operations conclude. The propaganda benefits of providing aid can be seen as so valuable that conflict is suspended during these events. For example, during the 2005 Indonesian tsunami response, the Free Aceh Movement (GAM) rebels offered a truce when the government began restricting aid delivery [78]. A similar truce occurred in Sri Lanka, where the Tamil Tigers and the government agreed to share responsibility for aid to disaster survivors [79].<sup>13</sup>

However climate change may change this calculus in the future. If rapid-onset disasters—for example, tropical windstorms (hurricanes, typhoons) in the Caribbean and Indian Ocean—increase in frequency or intensity, the likelihood that such events will occur in unstable countries will in turn increase. As climate change decreases the overall stability of countries, and increases the number of rapid-onset disasters, the probability of disaster response operations occurring in areas of conflict increases. This less stable environment would affect responses to climate induced disasters, as well as the “normal” disasters that would occur without climate change. These “complex disaster response” (CDR) operations are uncommon today, but may become more common in the future.

While prediction of conflict is virtually impossible, the mission of future response forces may change from permissive to complex disaster response.

### **Complex disaster response (CDR) operations**

In responding to CDRs, the first question is: What will the operating environment be? Because time is critical in most disaster response operations, responding forces will not have the time or capability to deploy large security elements in advance. In CHEs, it is possible for military and other security forces to work with relief organizations to establish convoys and secure zones where aid can be delivered. Forces are also able to spend time identifying possible threats and engaging them before aid operations reach those areas.

In CDRs, response forces may need to enter areas where active threats have not been engaged or neutralized. This means that either response forces will be at risk, or they will need additional security—which increases overall force requirements as well as the cost of delivering aid. This may also decrease potential aid flows as security force logistics occupy slots that may have been available for relief logistics. It may also divert aid to security operations, or security threats may

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13. Even so, the truce and the overall record of the Tigers took a different trajectory than the GAM, with accusations of the Tigers recruiting orphans and siphoning aid money for weapons [80].

cause attrition of aid before it gets to the intended recipients, further increasing the cost of delivering aid and decreasing the overall amount of aid that can be delivered.

Because events generally cannot be predicted very far into the future, response forces and supplies will flow into the disaster area over time. If forces or supplies have to be diverted to deal with a security threat, the overall timeline and buildup for the event may stretch out, the effort may grow, or the amount of aid delivered may decrease.

If there is a transition in the future from disaster response operations in benign environments, to operations in areas under security threats, then either additional forces and capabilities will be required, or the rate of aid delivery will decrease. This may be the most predictable effect of the combination of climate change induced instability and increased numbers of rapid-onset disasters. Rapid-onset disasters will become more like slow-onset disasters, in that both will face security threats.

While security threats can increase the cost of delivering aid, they can also increase the cost to the military of supporting an aid operation. If disaster response operations become complex due to increased instability, the type and number of units deployed in support of CDR operations will change. Likewise, if instability increases security threats in humanitarian operations, thereby increasing the number of CHEs that must be responded to, the force mix will be further affected. While the US military has considerable capability to deal with CDR or CHE threats, the cost in terms of the comparative number and nature of the units deployed may increase DoD's cost for the deployments. This could increase stress on operational funds, or increase DoD's reluctance to engage in CHE or CDR missions that are not clearly tied to national security.

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# What does the military do in disaster response?

In this section, we examine past military operations in order to identify the type, scale, and duration of military disaster response. If operations are going to increase in number, or change in type or intensity, a study of historical data can be a starting point for projecting future demands and challenges. Likewise, past data on military operations provide insight into decision-making about military forces commitment, and how these operations might evolve in the future.

## US military foreign disaster response 1970-2008

The United States military has engaged in a wide range of response missions each year. These have ranged from single unit or aircraft “token” responses, to large-scale missions involving many thousands of personnel, large quantities of equipment, and complex logistics. In examining how the US military has responded, we will need to know *why* it has responded. Unless we understand why US military forces have been committed in the past, it will be difficult to understand how they might be used in the future. Thus, in this section we will examine three interrelated topics:

- The decision-making process the US government employs when deciding whether and how to respond to a disaster and considerations concerning whether and how to employ military forces in a response.
- Past US military disaster response operations, to determine how the military has been used to respond to disasters. We characterize these responses according to disaster type, severity, responding service, location of the disaster, and the response.
- Factors that drive the use of military assets in disaster response, and how these factors may impact future response decisions.

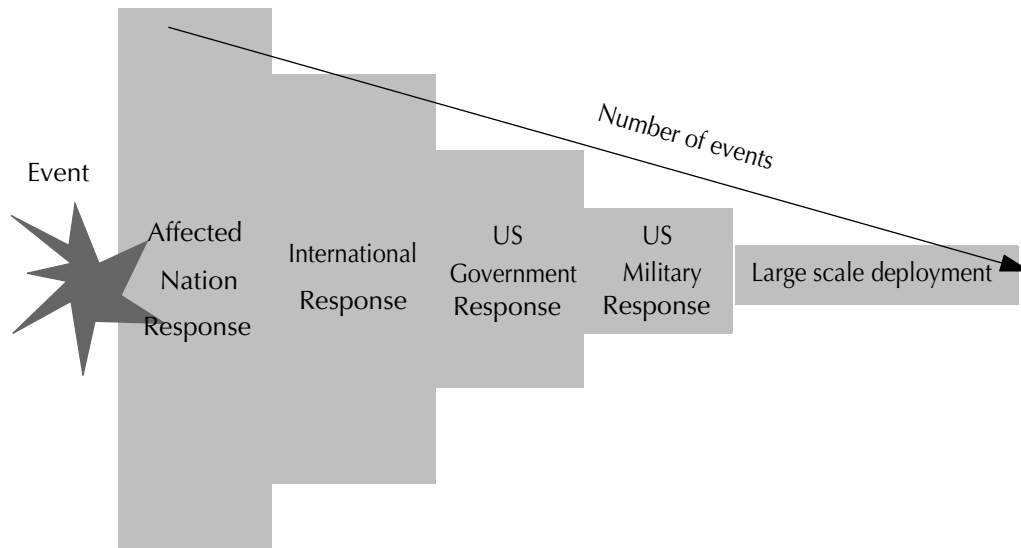
## Decision-making process for foreign disaster response

The US military has long been involved in foreign disaster response operations, responding to a range of disasters, including man-made disasters, natural disasters, and complex humanitarian emergencies. Yet, it is clear that the US military does not respond to every disaster that occurs. For example, in 2005 approximately 500 natural disasters were reported worldwide [81], and the US government reported that it responded to 79 natural disasters [82]. Yet the US military was involved in only 6 responses. Thus, it is clear that the US military is only used to respond to disasters selectively, and the US government has a choice about whether to employ military forces in disaster response. This section explains the framework that governs how the US government decides to employ resources during foreign disaster response, and how the decision to use military assets fits into this framework.

### International framework

Internationally, the USG is only one responder to disasters. When a disaster strikes, the first step is for the host nation to determine whether it can deal with the disaster using its own resources, or whether it needs to request international assistance. Depending on the country, indigenous actors may be able to handle a disaster response themselves. If an afflicted country decides that it cannot provide adequate disaster assistance, it may appeal for international assistance. Many actors in the international system have the capability to respond to disasters, including UN organizations, NGOs, and state agencies. Figure 6 illustrates the global response framework and how the US government fits into the international response effort [9]. As can be seen there, the total number of events that ultimately result in either a US military response, or a large-scale deployment of resources, is small compared to the large number of events that happen each year.

Figure 6. Global response framework illustrating the relative number of events responded to by various national, international, and United States organizations



## USG framework

The US government has a process for determining whether US resources will be used to respond to a disaster. The State Department manages the overall US foreign disaster response effort, and within the State Department, USAID's Office of Foreign Disaster Assistance (OFDA) is the lead office responsible for coordinating disaster assistance efforts across the USG.

When a disaster strikes, the first step in the response process is the declaration of a disaster by the US Ambassador in the affected country. In order to declare a disaster, the following criteria must be met [83]:

- The magnitude of the disaster must be beyond the capacity of the host country to respond to.
- The host country must request, or be willing to accept, assistance.
- A response must be in the interest of the USG.

Once a disaster is declared, OFDA can immediately provide up to \$50,000 to the US Embassy in the affected country for relief. At this point, OFDA will assess whether it needs to take further action. If the disaster is severe enough, OFDA will likely deploy a Disaster Assessment Response Team (DART) to assess the situation and coordinate with other relief organizations. Once the DART has completed its assessment, it will consider options for action. Depending on the type and scale of the disaster as well as the specific needs identified, OFDA can reach out to other USAID bureaus, such as the Office of Food for Peace, or the Office of Transition Initiatives, or to private contractors, to provide needed materials, personnel, and resources. In theory, OFDA requests DoD assistance in disaster relief only after it determines that civilian agencies cannot provide appropriate support.

DoD can perform several response roles independently of USAID/OFDA. First, after a disaster strikes, the regional Combatant Commander may choose to dispatch a Humanitarian Assistance Survey Team (HAST), to the affected area. Because the military is prepositioned around the world, the HAST may be the first USG team to arrive. In other cases, the HAST assessment may be concurrent with OFDA's DART assessment. Once the assessment is complete, the Combatant Commander can deploy forces at his discretion.

The US military may act outside the USAID/OFDA process if the US Ambassador to the affected country requests assistance directly from the regional Combatant Commander. Such a request was made in the aftermath of an earthquake and tsunami which hit the Solomon Islands in 2007. The Ambassador to the Solomon Islands requested assistance directly from the PACOM Combatant Commander, and PACOM immediately deployed USNS *Stockham* (T-AK 3017) to the affected area. In this example, the deployment proved to be premature. USAID/OFDA and DoD agreed that the scale and scope of the disaster did not warrant the response [84].

Such examples demonstrate the possibility of confusion about how the US military is to be used during a disaster response. Is the military only to be used as a measure of last resort, or is it to be used as a symbol of public diplomacy? Is it a security force, or can its capabilities be used to support logistics delivery? For how long?

Debates about the role of the military in humanitarian and disaster operations occur both within the Department of Defense and within the broader interagency. The trade-offs involve the potential for decreased readiness for combat missions due to units being removed from their training and deployment cycles, compared to the goodwill generated by effective response to emergency events. As a result, generally the US military engages during the early phases of a response, but quickly leaves after the situation has become stabilized. The primary exception to this is when it needs to continue providing security operations in complex emergencies.

## Implications of the decision frameworks

Our examination of the disaster response decision-making framework leads us to the following conclusions:

- The USG is not required to respond to foreign disasters. If it does respond, the US military is only one of the tools available, and a number of decisions must be made before it is considered as a responder.
- The decision is usually made in OFDA, and is thus a political decision [85]. Many considerations can influence it, including national security interests surrounding the event and those populations affected,<sup>14</sup> availability of assets,<sup>15</sup> level of need, and sense of urgency.<sup>16</sup>
- In theory, the military should be called upon to respond only after all other options have been exhausted; however, it is often not used in this way [84].

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14. For example, the large-scale response by the United States to the 2005 tsunami was partially driven by the desire to engage and support the large Muslim populations that were affected.

15. In the case of Operation Sea Angel, the 1991 response to Cyclone Marian in Bangladesh, the units responding were returning from deployment as part of the Gulf War and were immediately available.

16. The decision to intervene in Somalia was driven as much by need as by the “CNN effect,” though both were most likely operating to push the United States into intervening [86–87].

## US military responses to natural disasters

We now examine past foreign disaster responses, characterizing them by the type of disaster, its severity, the responding service, the location of the disaster, and the presidential administration in office when the response occurred.

In order to examine past responses, we created a database of US military foreign disaster responses during 1970–2008. The main source of data is a CNA database containing all US responses to situations between 1970 and 2003 [5]. We extracted the disaster responses from this database and used the following sources to supplement the database and add information from 2003 to 2008:

- USAID OFDA yearly reports
- RAND report MR-951 [88]
- SOUTHCOM web site
- Reliefweb database of response pledges
- List of DoD humanitarian responses eligible for medals.

We used two criteria for selecting responses to include in the database:

- The response was a humanitarian or disaster response mission.
- The response was to a specific situation or event. We excluded cases of general aid, such as excess property donations, where there was no evidence of an initiating event.

A total of 315 US military response operations fulfilled the above requirements, and we included all of these operations in our database. Of the 315 responses collected, only 258 had enough information that we could determine the level of effort of the US response. In many of these cases, we were unable to determine how many troops or assets were used during the response. Therefore, when level of effort is a factor in our analysis, we include only those 258 instances where we had enough information to characterize the response's level of effort.

Additionally, while we gathered as much information about humanitarian operations as possible, it is clear that our analysis does not include every instance of US military foreign disaster response. The database is not a complete historical record of responses, but rather a sampling of responses. For this reason, we look for general trends in the data and general response patterns, and do not do a rigorous statistical analysis of the data.

## Character of US responses

To characterize the responses, we first counted them according to the type of initiating disaster. In table 2, we list all 315 responses included in the database according to disaster type. We further group the responses into three categories: natural disasters, chronic disasters, and industrial disasters.

Table 2. Number of responses by type<sup>a</sup>

Disaster type	No. of responses
<b>Natural</b>	<b>231</b>
Avalanche	2
CO2 release	1
Earthquake	45
Flood	78
Forest fire	6
Insect infestation	4
Landslide	6
Tropical storm <sup>b</sup>	77
Tsunami	2
Winter storm	4
Volcanic eruption	6
<b>Chronic</b>	<b>68</b>
Civil war/conflict	17
Disease	10
Drought	11
Famine	11

Table 2. Number of responses by type<sup>a</sup> (continued)

<b>Disaster type</b>	<b>No. of responses</b>
Refugees/migrants	19
<b>Industrial</b>	<b>18</b>
Bridge collapse	1
Gas/oil explosion	5
Infrastructure fire	3
Nuclear accident	3
Plane crash	5
Ship accident	1
No data	7

a. Nine disasters had more than one cause and were counted twice in this chart.

b. Includes hurricanes, cyclones, tropical storms, and typhoons.

Rapid-onset natural disasters make up over two-thirds of US military disaster responses. Although the military responds to a wide range of disaster types, the vast majority of responses are to floods, tropical storms, and earthquakes.

In contrast, slow-onset disasters and associated humanitarian emergencies make up just under one-quarter of all responses, with civil conflict and refugees/migrants having the highest numbers of responses.

Industrial disasters account for only about 6 percent of US responses, and involve events such as plane crashes, nuclear accidents, and infrastructure fires.

### **Levels of effort**

Simple numbers of events and responses do not necessarily suggest how taxing the efforts are for the military. It is the total effort involved, both in terms of numbers as well as the duration that determines the overall stress on the force.

In order to characterize the scale and duration of US military responses, we first grouped responses into nine categories based on the level of effort of the response. We characterized the level of effort based upon the duration of the response and the number of assets used.

For duration of the response, we created three categories:

- One week or less
- Between one week and 90 days
- 90 days or more.

For assets, we used the following definitions:

- Low: for the Air Force, 5 aircraft or less; for the Navy, a Seabee detachment; for the Marines, a squadron or company; for the Army, a HAST.
- Medium: for the Air Force, 5–20 aircraft; for the Navy, 1–3 ships; for the Marines: Marine Expeditionary Unit (MEU, approximately 2,200 Marines) or other Marine detachment; for the Army: a battalion (300–1,000 soldiers) or brigade (3,000–5,000 soldiers); or, a combination of “Low” assets.
- High: for the Air Force, 20+ aircraft; for the Navy, 4+ ships; for the Marines, a Marine Expeditionary Force (MEF, 47,000 sailors and marines) or Marine Expeditionary Brigade (MEB, 4,000–16,000 sailors and marines); for the Army, a division (10,000–15,000 soldiers); or, combination of “Low” and/or “Medium” assets.

Using these definitions, we created a matrix that includes nine levels of effort, as shown in table 3. In table 3, we code each entry in the 3-by-3 matrix of assets and duration with a number reference. This gives us a continuous progression of “level of effort,” moving from a low number of assets and a short duration (category 1) to a large number of assets and a relatively long duration (category 9). In the following figures we will use the level of effort to better understand how various types of disasters and humanitarian responses affect military forces.

Table 3. Framework coding for the nine levels of effort, accounting for both assets and duration of the event

Assets	Duration		
	=< 1 Week	> 1 week and =< 3 months	> 3 months
Low	1	2	3
Medium	4	5	6
High	7	8	9

Table 4 shows the corresponding numbers of events that occur in each of our level of effort categories.

Table 4. Number of events in each level-of-effort category

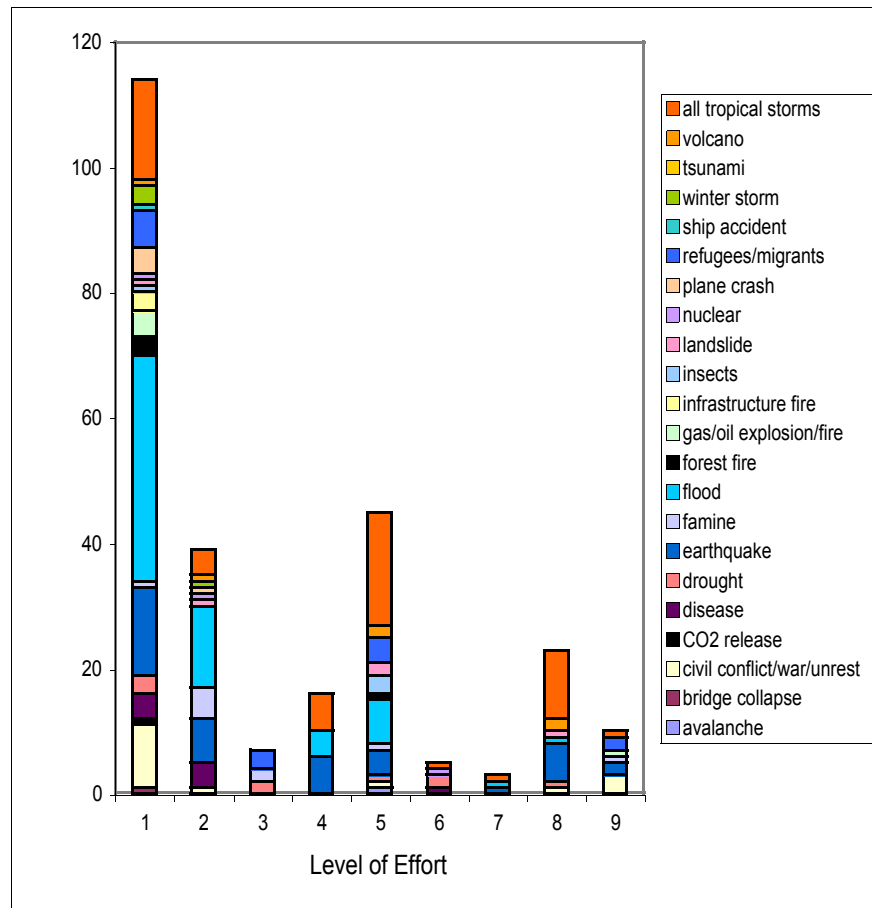
Assets	Duration		
	=< 1 Week	> 1 week and =< 3 months	> 3 months
Low	114	37	7
Medium	17	42	5
High	3	23	10

Table 4 shows that the highest percentage of disaster responses, 44 percent, are in the lowest level-of-effort category—that is, they take less than a week and use only a low number of assets (category 1). Many of these low-level-of-effort operations are conducted by the Air Force and involve small-scale lift of humanitarian supplies. The next-highest percentage of responses, 40 percent, are in the medium duration category. We also observe that few disaster response operations last longer than 3 months. Because they involve longer duration and larger-scale events, the number of assets involved in these responses also increases. In the following sections, we will use this framework to further characterize the responses included in our data set.

### Disaster type

As climate change will predominately affect weather-related events, figure 7 shows the distribution of different types of events according to the level-of-effort measure.

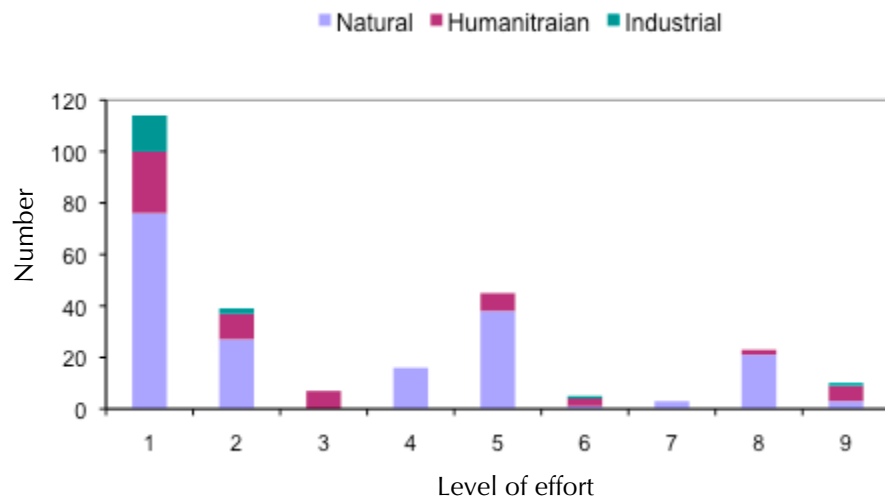
Figure 7. Disaster type by level of effort



Disaster responses at the lowest level of effort (category 1) follow the overall trends in terms of disaster type; floods, tropical storms, and earthquakes account for the vast majority of responses. In addition, responses of the shortest duration and at a medium to high level of effort (categories 4 and 7) have only been to these three most common disaster types. A relatively large number of responses are in categories 5 and 8. But in both categories, nearly half of the responses are a result of tropical storms. Although there are few long-duration responses (categories 3, 6, and 9), over half of these responses are to more chronic events, such as drought, famine, and disease.

To better understand the potential effects of climate change on response requirements for different types of disasters, we plot natural, humanitarian, and industrial disasters in figure 8.

Figure 8. Level of effort according to disaster type



We can see in figure 8 that disasters requiring long-duration responses (levels of effort 3, 6, and 9) tend to be slow-onset in nature and call for humanitarian relief efforts. Rapid-onset disasters (i.e., natural disasters) tend to require short-duration responses (levels of effort 1, 5, 7) and medium-duration responses (levels of effort 2, 5, 8). There are several reasons for this:

- Most slow-onset disasters are made up of a complex set of economic, social, and military issues, all of which tend to require that the response be lengthy and complex.
- Rapid-onset disasters by definition do not give much warning before they occur. This means that the planning and preparation time available is less, and the response is more ad-hoc and

less deliberate. This shortens the overall timeline for the initial response.

- The objectives of a rapid-onset response are better defined, which can result in a well-defined end-state for the initial response. For slow-onset, humanitarian responses, the lack of a clearly defined objective and end-state can lead to longer-duration responses.

Figure 8 suggests that the military is tasked with a wide variety of short-duration responses, but that longer-duration responses tend to be humanitarian relief in the aftermath of slow-onset events.

### **Disaster severity**

To understand how disaster severity may impact the type of response, figure 9 categorizes tropical storms, using the Saffir-Simpson scale as a measure of severity. This scale uses wind speed to determine the level of a storm, and thus, does not provide a complete picture of the storm's severity (which can also be measured by the amount of damage done, the number of acres destroyed, or the number of deaths caused). However, it is a generally agreed upon scale that helps us understand how severity may affect the level of response.

As figure 9 shows, more-severe storms (categories 4 and 5) get more responses than less-severe storms. We also notice that for the most-severe storms (category 5), responses tended to be at a higher level of effort (medium duration, and medium or high allocation of assets).

This is significant because one of the primary predictions for tropical storms is that their frequency or number may not be greatly affected by warming but their overall intensity may increase. If the military tends to respond to high-intensity storms more frequently, the military responses may increase due to warming trends.

### **Trends among the services**

We also found differences in level-of-effort trends among the various services of the US military. Figure 14 demonstrates which services responded to disasters at each level.

Figure 9. Tropical storm responses according to level of effort (categories 1-9) and severity of the storm (Saffir-Simpson scale 1-5)

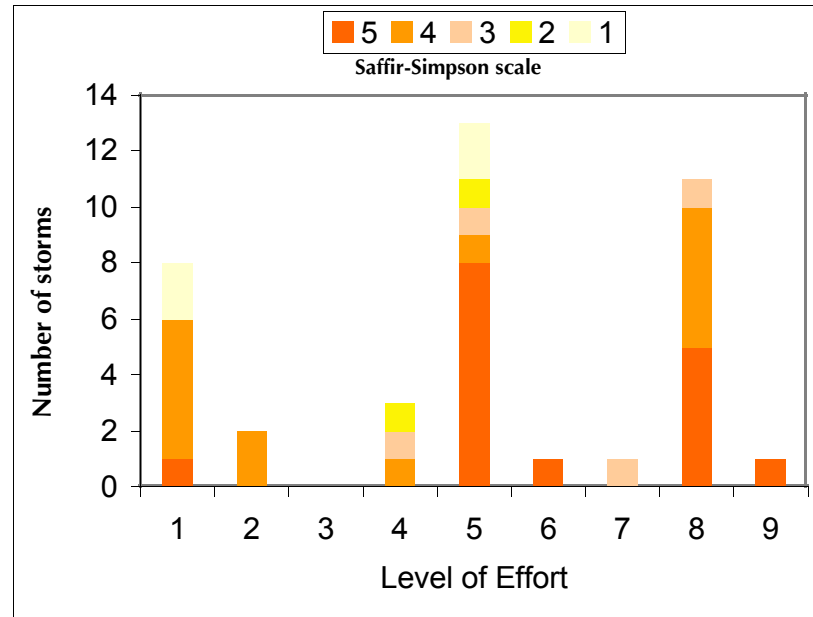
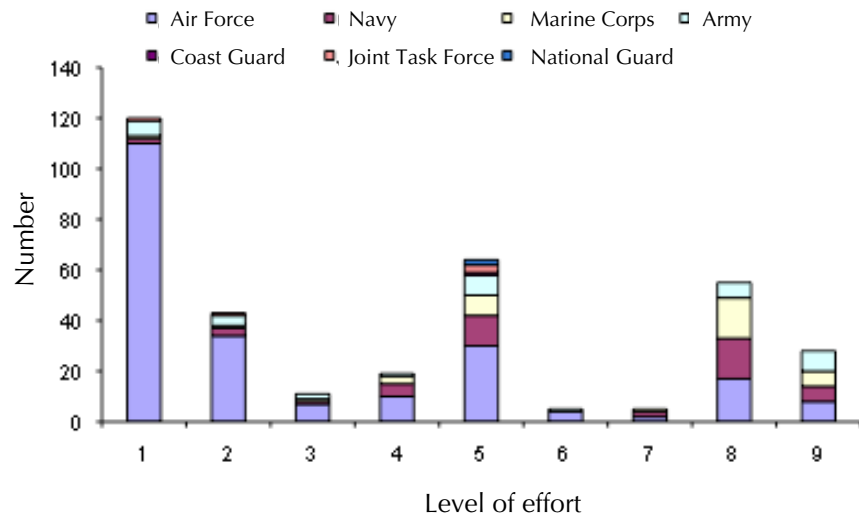


Figure 10 shows that the Air Force performs many of the US military disaster response operations. The predominance of the Air Force is especially noticeable in responses requiring few assets and a short duration (level 1). This trend is likely due to the flexibility of Air Force assets to respond rapidly, with little presence. Most Air Force responses are airlifts of humanitarian relief supplies. Often, the Air Force will send only a single plane loaded with these supplies.

Navy and Marine Corps responses tend to follow similar trends, providing a medium or high level of effort for a medium duration. This demonstrates two factors in Navy and Marine Corps response. First, when a ship is called upon to provide disaster relief, it is usually diverted from its regular deployment path and may require a few days of travel time to the affected area. Second, because these assets are generally diverted from their primary missions to take part in disaster response efforts, they are limited in the amount of time they can spend performing relief activities.

Figure 10. Responses by service and level of effort



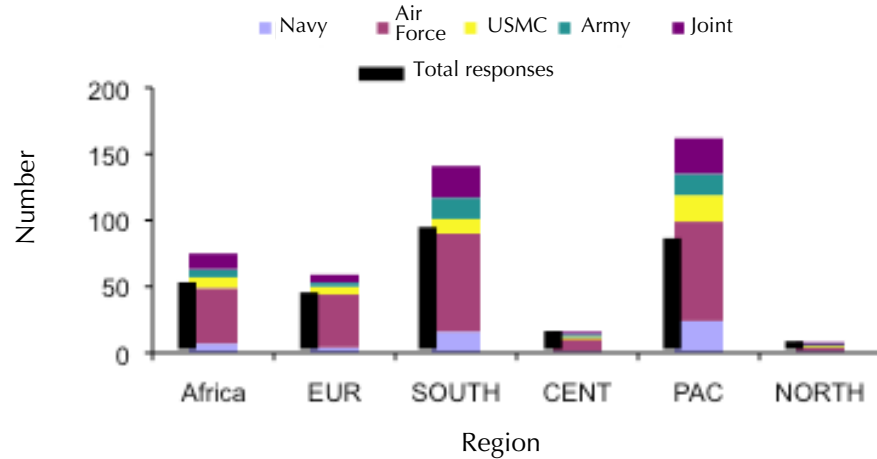
Of all the major services, the Army participates in the fewest disaster responses, and these are almost always joint. This is likely due to the less expeditionary nature of Army forces. We observed that the Army tends to respond when it is already stationed close to the site of the disaster. Of note, Coast Guard and National Guard assets are sometimes used in foreign disaster response as well, but in small numbers.

### Where

We categorized responses by service and Area of Responsibility (AoR) in order to learn where US military assets are used in disaster response (see figure 11). Because AoR boundaries have changed over time, we used the current (FY 2009) Unified Command Plan definitions.

Most disaster responses occur in the PACOM and SOUTHCOM AoRs. These regions tend to have many tropical storms (and for the Pacific, earthquakes) and countries there often have less-developed disaster response capabilities when compared to such regions as Europe.

Figure 11. Response by region and service<sup>a</sup>



a. The total number of responses is less than the sum of the individual service responses because more than one service can participate in a single response.

There was little difference in the distribution of service responses across AoRs. The exception to this trend is that the Navy and Marine Corps' share of responses was slightly higher in PACOM than in other AoRs, and PACOM had a higher share of joint responses than any other AoR.

Categorized by AoR and level of effort (as in figure 11), the data indicate that nearly half of all long-duration responses occurred in the African AoR, and another third occurred in SOUTHCOM. Looking more closely, we see that all the long-duration responses in the African AoR were associated with chronic disasters, including civil unrest, famine, and drought. For SOUTHCOM, long-duration responses were more evenly split between chronic (57 percent) and natural (43 percent) disasters. While most of the disasters the US military has responded to in the past have not been in the African AoR, a significant portion of the disasters it has responded to there have required a long-duration response and have been associated with chronic disasters.

## When and Why

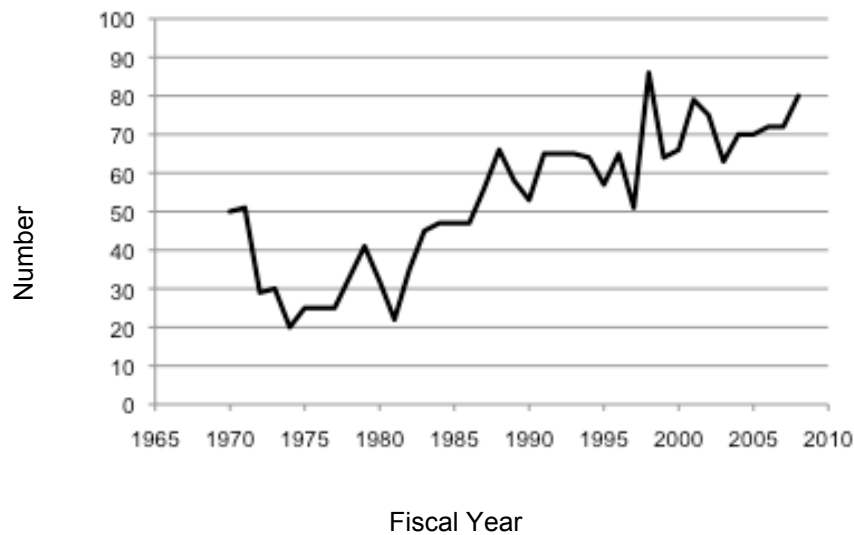
Do US disaster responses follow some trend, either in the number or some casual relation with political decision-making?

Counting disasters and humanitarian emergencies is complex. In any given year there are innumerable events around the world which could be called “disasters” or “humanitarian emergencies.” Some of these are declared locally, fewer are declared by the UN, and even fewer reach a high enough level to receive an OFDA disaster declaration. To make things more complex, in any given fiscal year (which is how OFDA counts them) a number of events are ongoing from the previous year and new events are added to the mix. Also, as we see with military responses, simply counting numbers does not necessarily equal effort; the responses for any number of small disasters might together barely equal the response for a major tsunami or typhoon.

To determine how disasters have evolved, we base our total count of disasters on the number of OFDA-declared disasters. Responses could be as small as an ambassador authorizing a minimum contribution to a local relief effort, or as large as participating in an international relief effort. OFDA-declared disasters at least indicate those events that the US government is interested in, and can form a baseline for comparison with military relief efforts. In figure 12 we plot the number of OFDA-declared disasters from 1970 through 2008. As can be seen in the figure, the total number of disasters and humanitarian events that the US government has officially participated in has been increasing, from 20–30 per fiscal year in the 1970s, to 70–80 per FY during the current decade.

If use of military forces is a consistent component of disaster response, we would expect that the fraction of disasters with a military response component would be relatively constant over the years and political administrations. If, however, the use of military forces is dependent on other factors, such as the international situation or domestic politics, we would expect wide variations in the use of military forces over a long period of time. In figure 13 we plot the ratio of interventions involving military forces to the number of OFDA-declared disasters. While this is not a perfect indicator of how military forces are used, the overall trend should indicate whether the use of military forces is consistent or varies widely.<sup>17</sup>

Figure 12. OFDA-declared disasters and humanitarian responses, 1970 through 2008 (by fiscal year) [89–90]<sup>a</sup>



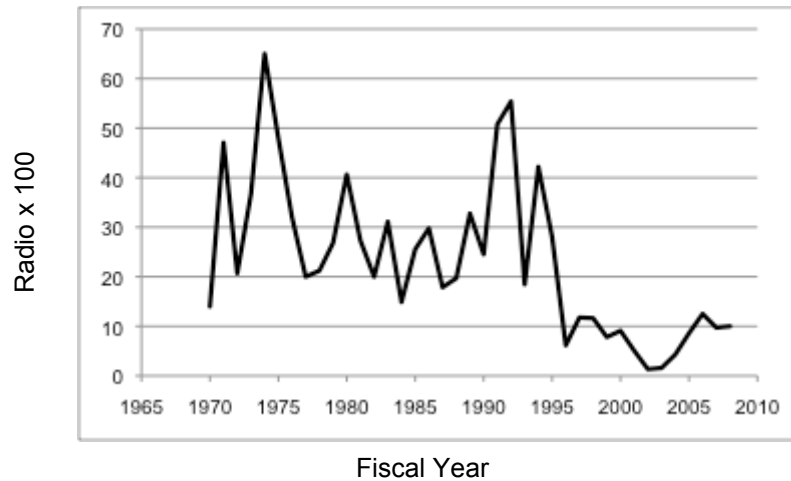
a. We used data from OFDA reports between 1993 and 2008. The 1991 report contains a summary of declared disasters back to 1964.

As can be seen in figure 13, the ratio of military interventions to OFDA-declared disasters is not linear. In fact, the ratio varies widely, from a low of 0–0.1 to a high of 0.65. The only identifiable trend appears to be a series of periods of high activity, followed by periods of relatively low activity. Given that the OFDA numbers follow a relatively linearly increasing pattern, the driver for this variability is the number of disaster response or humanitarian missions that the military undertakes. Essentially, the number of military missions varies widely, year by year, in a somewhat saw-toothed pattern.<sup>18</sup>

17. Our main goal in taking the ratio of military responses to OFDA declarations is to normalize out the effect of number of disasters on the decision to commit military forces. It is possible, for example, that in one year there were an exceptional number of disasters, resulting in a larger number of military responses. As figure 12 shows, however, the total number of disasters does not vary widely, and has tended to linearly increase over time. We see exactly the opposite trend for military responses: their number varies widely and shows no discernible increase over time. This suggests that the total number of disasters is not a relevant variable when considering the decision to commit military forces.

18. This variability is shown in the absolute number of military responses, which follow a pattern similar to that seen in figure 13.

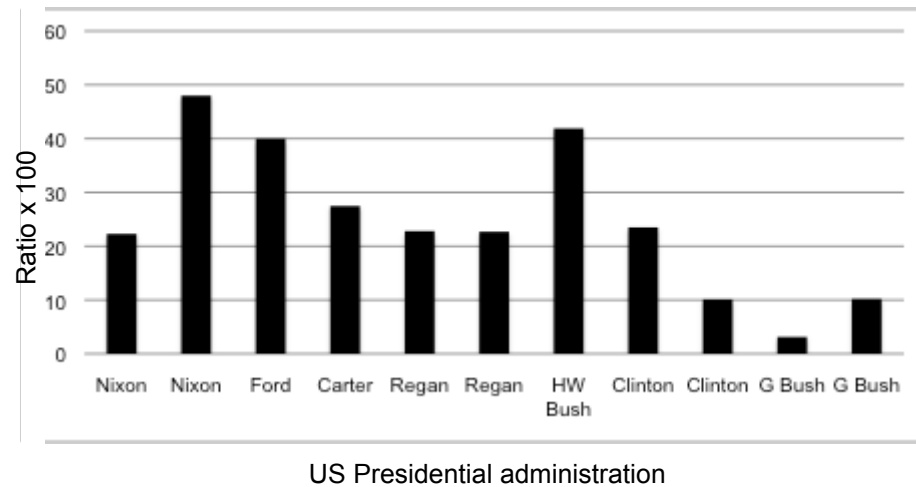
Figure 13. Ratio (as a percentage) of the number of disasters or humanitarian emergencies involving US military forces to the number of OFDA-declared disasters, by fiscal year



One possibility is that domestic United States political parties influence how the military forces are used. As any commitment of US forces is a Presidential decision, the decision is in itself inherently political. In figure 14 we plot the ratio (expressed as a percentage) of disaster and humanitarian responses involving US military forces to the number of OFDA declarations. In the chart, we had to round the Presidential term to the nearest FY in order to reconcile the different data sources.

As can be seen in figure 14, there is no particular relationship between the political party of an administration and the ratio of interventions using military forces. Even within an administration the ratio can vary widely, as is the case with the Nixon and GW Bush administrations.

Figure 14. Ratio (as a percentage) of military disaster and humanitarian responses to OFDA-declared disasters, by US Presidential administration



In terms of presidential administration, no constant trend exists. Clearly, the number of disaster responses over time and in each presidential term has varied widely. This trend (or lack thereof) suggests that disaster response is determined not necessarily by partisan politics, but perhaps by other political factors, such as foreign policy. This is consistent with theories that domestic politics play a small role in the decision to commit US military forces, with international considerations playing a more significant role [91].

For example, in this chart, we can see that a drastic drop in the number of responses roughly corresponds with the end of the Cold War. While we cannot isolate this factor as the sole cause of decreased responses, it is clear that the decision to respond depends upon more than presidential administration.

In further examining individual responses, we found that the decision to respond could include such considerations as US foreign policy concerns (the current relationship between the recipient and the US, the political system of the affected state, and the level of development in the affected state), and domestic influences within the US

(budget deficit, salience of the disaster) [85]. Additionally, national security interests, availability of assets, and the level of need and sense of urgency could all influence the response decision.

To demonstrate the complexity of determining the exact motivation for US military involvement in a disaster response operation, we offer three brief examples: Operation Sea Angel in 1991, the US military intervention in Somalia, and relief efforts following the 2005 tsunami in southeast Asia. While we will not detail every factor involved in the response decisions, we will identify some driving factors for each response in order to demonstrate the range of factors present.

In the case of Operation Sea Angel, the 1991 response to Cyclone Marian in Bangladesh, two readily identifiable factors may have influenced the decision to provide disaster relief. First, the Bangladeshi government had made the transition to civilian rule one month before the cyclone hit, and the damage caused by the cyclone could have threatened the government's stability [92]. Second, the responding units were returning to the US from deployment to the Gulf War and were immediately available.

The decision to intervene in Somalia was driven as much by need as by the "CNN effect," though both likely helped to push the United States into intervening [86–87]. The humanitarian crisis in Somalia was dire: in July 1992, the International Committee of the Red Cross estimated that one-third of all Somalis were in danger of dying from starvation. At the same time, major media outlets in the US began to publish articles about the humanitarian situation in Somalia accompanied by pictures of starving children [93]. While it is difficult to determine the exact cause of US intervention, these factors contributed to the US responses of first airlifting humanitarian supplies and then deploying ground forces.

US military forces do not always intervene, as illustrated by the Darfur emergency in Sudan. Despite the ongoing complex emergency that exists in Sudan [93], the US government has not committed military forces to stabilize the security situation, though it has provided logistics support to the United Nations [94–96]. Instead, a coalition of African countries under the United Nations (United Nations Hybrid Operations in Darfur) has been providing security and assistance in

support of stabilization [97]. US military forces' decision to intervene, even to provide logistics, was coincidental with statements made by the incoming Obama administration about their willingness to intervene in Sudan [98]. The situation is further complicated by the presence of China in the region, the role of Sudan in the war on terrorism, the complexity and difficulty of resolving the conflict, and the other conflicts currently engaging US forces in Iraq and Afghanistan.

The large-scale response by the United States to the 2005 tsunami was influenced by several factors, including the immense size of the disaster, the long-standing relationship between the Indonesian armed forces and US armed forces, and the US desire to engage and support the large Muslim populations that were affected. The destruction caused by the tsunami was massive, and the Indonesian government recognized that it did not have adequate capabilities to respond. The five countries that Indonesia initially approached for assistance, Australia, Malaysia, New Zealand, Singapore, and the US, were chosen based on their existing ties with Indonesian armed forces as well as the capabilities they could provide [99].

## Summary of characterizations

Several themes stand out in the characterizations of past disaster responses.

- The flexibility of Air Force assets to respond to a wide variety of disaster types and in a wide variety of AORs is clear.
- At least for tropical storms, responses at a higher level of effort tend to correspond with more severe storms. Responses to many severe tropical storms are at a medium or high level of effort (levels 5 and 8).
- Although not employed as often as the Air Force, Navy and Marine Corps assets tend to be used during responses with a higher level of effort (especially levels 5 and 8). Furthermore, these same responses are often to tropical storms occurring in PACOM or SOUTHCOM AORs.
- Long-duration responses tend to be associated with chronic disasters.

- The number of responses varies from presidential term to presidential term, but there was a sharp decrease in responses during the late 1990s.

## Implications

When considering how US military forces may be used in the future, several trends in the historical data are important:

- While the decision to intervene is a political one, it appears to depend on factors unrelated to presidential administration. These factors could be perceived need, or various elements of the foreign policy process.
- Very few interventions involve US military forces; however, those that do can be large in scope and require long-duration deployments.
- Africa and SOUTHCOM have seen the largest number of long-term humanitarian assistance deployments.
- Storms at the higher end of the Saffir-Simpson scale are more likely to see responses than those at the lower end.

Trends from climate data suggest that Africa will be significantly affected by climate change, and that the intensity of storms will increase. This suggests that pressures for additional assistance may increase, including deployment of military forces. At the same time, the willingness to commit US forces varies by a factor of three or more over time. The willingness to commit forces appears to depend on the availability of forces, the need, and other, unknown, factors. How these will interact with increasing pressures from climate change cannot be determined.

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# The military's unique role in disaster response

The US military can perform a wide range of missions during a disaster response. It can respond virtually anywhere, at any time, to any type of event. However, there are many other organizations and entities that can, and do, respond to rapid-onset disasters. Key questions are:

- What unique capabilities does the US military bring to response and recovery operations for rapid-onset disasters?
- How will the demand function for those unique capabilities change in a warming climate?

In this section we review four key functions that the military can bring to relief or humanitarian operations: command, control, and communications; security operations; tactical transport; and theater lift. Many of these functions can also be provided by others, and we will discuss what is and is not unique about US military capabilities.

In addition, the US military has a planning and training process—one that could be adapted to better understanding the requirements for response operations in the event of climate change. We will also discuss this process, and how it might be applied to help develop skills within the overall response community.

When considering what capabilities the military brings to disaster and humanitarian response, it is important to distinguish unique capabilities from the sum of all capabilities that military forces possess. The United States military possesses a wide range of applicable capabilities ranging from mapping to contracting and heavy equipment operation. Medical capabilities are often seen as a major contribution by military forces in disaster and humanitarian response operations. However, military medical capabilities are essentially the same as those of many non-governmental organizations, as well as those of the local nations affected by the disaster.

Thus we do not consider medical capabilities to be a unique capability. Instead, it is the ability to support those medical capabilities in an expeditionary environment that is the unique capability of the US military (though some NGOs share that capability as well). The supporting functions of command and control, operational logistics and tactical lift give the military an expeditionary medical capability and are thus considered here to be the core unique mission contributions that the military makes to disaster and humanitarian response operations.

## **Command, control and communications**

To coordinate aid delivery across large geographical distances, operators must be able to communicate. Communication is critical between groups in the field and the country operations center; between different national, regional, and international groups involved in the response; and between various links in the logistics chain that is delivering the relief aid. Civilian communications infrastructure may not always respond quickly enough to establish video, voice, and data connections in underdeveloped areas or in areas affected by disruptive events.

Military forces have communications assets that are designed to deploy to underdeveloped areas and quickly establish connectivity. These capabilities can support military, civil government, and non-governmental disaster response organizations. For rapid-onset disasters, deployable communications capabilities mean that military forces may be the first on the scene with the greatest capability to communicate. For slow-onset disasters, military communications can provide greater bandwidth and wider coverage, plus other capabilities that civilian systems may lack.

At the same time, a range of communications capabilities, from cellular telephone to satellite, can provide emergency, portable communications in the disaster area. The primary difference between these systems and military ones is that the military systems come packaged with power, data processing, and communications reliability capabilities that would be additional requirements for most civilian communications systems.

As relief operations have grown more sophisticated, the need for military capabilities has decreased. Deployable communications assets that were once unavailable are now within the capability of major aid organizations.

## Theater lift

Theater lift is the ability to transport large quantities of material and personnel long distances. For the military, this could mean using aircraft to fly in emergency supplies, or it could mean using sea transport to move heavy construction or support equipment. Examples include the movement of fire-fighting supplies to Australia by aircraft to fight the 2007 wildfires, or the activation of Maritime Prepositioning Squadron ships as part of the 2006 tsunami response.

This is another area where civilian capabilities duplicate or overlap military ones. The World Food Programme (WFP), for example, runs an extensive logistics infrastructure for moving emergency supplies and food around the world. It operates Humanitarian Response Depots, which house WFP's supplies as well as those of other humanitarian groups. It can ship its own supplies, or those of other groups, through its Ocean Transportation Service (OMLS) or through the United Nations Humanitarian Air Service (UNHAS). These capabilities use commercial equipment to provide extensive lift capability.

The most significant difference between military forces and civilian capabilities is the ability of forward-deployed military units to react quickly in the event of a rapid-onset disaster, arriving on-scene before civilian assets can deploy from centralized locations. However, many of the military's forward-deployed capabilities, such as prepositioning ships, hold cargo and equipment designed for warfighting. Only some of these (e.g., generators and food) have dual use in disaster relief.

## Tactical transport

Both communications and theater lift have civilian counterparts that can easily substitute for military capabilities. The civilian capabilities may not be as operationally agile—military ships and aircraft can

deploy faster and to less-developed locations—but the capabilities are essentially equivalent.

In rapid-onset disasters, tactical lift (mainly rotary-wing aircraft) is needed to distribute aid to areas where the transportation and communications infrastructure has been damaged or destroyed. For complex humanitarian disasters, ground vehicles can be used to distribute aid where infrastructure is intact, and rotary-wing aircraft can be used where infrastructure is non-existent, or where security threats prevent ground vehicles from operating. A mixture of helicopters and ground transport give operators flexibility in delivering aid, and allow them to overcome road and rail network problems.

Tactical lift occupies a border area in terms of what can be accomplished with civilian and military capabilities. WFP, for example, has operated helicopters to provide aid in rapid-onset disasters. In October 2009, WFP operated two Mi-171 helicopters out of Manila in response to Tropical Storm Ketsana and Typhoon Parma [100]. WFP deployed eight to twelve Mi-8 and one to two Mi-26 helicopters in support of the 8 October 2005 Pakistan earthquake; however, the cost of operations for the helicopters limited the number as well as the operational tempo of those deployed to Pakistan [101]. Likewise, most aid groups operate trucks and ground transport—for example, WFP operates sixty-three M621 6x6 all-terrain trucks in Haiti, to provide aid to less-accessible areas in the event of hurricanes [102].

Military aircraft and ground transport represent an additional capability that can augment civilian capabilities in certain circumstances. Specifically, military helicopters, ground transport, and sea transport can provide the following:

- Augmentation to civilian capabilities. A Marine Expeditionary Unit will have about twelve CH-46E medium-lift assault helicopters, four CH-53E heavy-lift assault helicopters, and a variety of utility helicopters. In addition, it will have 63 High-Mobility Multipurpose Wheeled Vehicles (HMMWVs) and 30 five-ton trucks. These units can significantly augment civilian and host nation capabilities already present. For example, a MEU would approximately double the ground transport capability that

WFP has deployed in Haiti in support of food delivery (not in response to the recent earthquake).

- Ability to reach isolated locations. Military forces can reach locations that may be difficult or impossible for civilian aircraft or ground vehicles to reach. For example, some locations in a disaster area may be beyond the unrefueled range of aircraft operating from the nearest civilian airfield. Military forces can establish temporary airfields and refueling locations, or operate directly from ships. Likewise, the military has special transport capabilities, such as Air-Cushioned Landing Craft (LCACs), that can operate from sea bases and reach unimproved shore locations that may not have landing zones or port access.
- Remote basing. Civilian capabilities generally require functioning facilities (runway, air traffic control, etc.) in order to operate for sustained periods of time. Military forces bring their own sustainment capabilities. For example, they can construct and operate an airfield in an unimproved location, or operate from a self-contained sea base. Thus they can operate independently of local infrastructure if necessary. While civilian organizations can duplicate that capability, it can be time-consuming and expensive.

Although the ability to provide logistics at the disaster site is not unique to the military, military forces do have tactical transport capabilities that cannot be easily duplicated by civilian organizations.

## Security operations

Military forces are designed to conduct operations in the face of ongoing hostile actions. They train and equip specifically for that mission. They have the unique capability to engage in a wide spectrum of violence, from non-lethal and less-than-lethal capabilities, such as riot or crowd control, to full-scale, high-intensity modern combat with integrated air/ground operations. Only nation-state military forces can engage in the full spectrum of security operations.

Aid organizations are primarily interested in delivering assistance, and thus take a range of precautions to avoid being targets of criminals or violent factions. In Somalia, the World Food Programme hired defensive guards and patrols from the local population [103]; on the other hand, the International Red Cross and Red Crescent rely on strict neutrality [104]. Most security actions taken by non-governmental organizations are defensive and preventative in nature. It would be very unusual for a non-governmental organization to actively attempt to disrupt a potential threat, for example.

Providing security for aid and relief is a mission for military forces, due to their capability, firepower, and authority to engage in security operations. There are many challenges associated with military involvement in security operations, however. These include:

- **Mission creep and mission leap.** Mission creep occurs when incremental additions, not originally planned, are imposed on a mission. For example, US forces originally entered Somalia for what they considered to be a humanitarian operation [86–87] but eventually became engaged in full-scale counter-insurgency operations as they sought to locate and neutralize the leadership of those forces who were targeting UN forces. Mission leap occurs when there is a sudden and dramatic change in tasking. In both cases, the military finds itself engaged in operations that it did not originally plan for, and often cannot easily disengage from.
- **Endstate.** It can be difficult to define when an operation is “finished” in a country experiencing an active insurgency. Often, as in Somalia, the military finds itself engaged in an initial task of facilitating aid deliveries, but ends up conducting full-scale counter-insurgency operations. These operations can go on for an extended period of time. Somalia, for example, is still wracked by internal conflict.
- **Multiple mission requirements.** As described above, military forces can provide for aid and relief delivery or they can provide for security. Conducting both missions simultaneously will further stress the required capabilities, increase the number of military personnel in country, and potentially decrease both

the initial willingness to commit forces and the pressure to make significant changes in the affected country.

All of these and other factors make the military's most unique capability—providing security—the most dangerous and difficult to deploy successfully.

## **Military planning and risk management capabilities**

The US military has developed a robust ability both to plan for various contingencies, and to conduct analysis and exercises in order to ensure that its forces can respond to those contingencies. These capabilities represent a potential model for identifying and planning for emerging or revolutionary changes in policy or threats due to climate change.

### **Planning**

US military planning is based on the joint planning doctrine, which describes both contingency planning, where possible events are identified in advance, and crisis action planning for emerging events. These planning processes allow military decision-makers to anticipate and manage both risks and requirements for a number of long-range options, while retaining the flexibility to adjust and adapt to emerging events [104–106].

The ability to identify and manage all the various potential risks, which is an essential element of contingency planning, represents a potential way in which the uncertainty in future forecasts could be managed. In the process of developing contingency plans, specific information sets such as event frequency or intensity can be identified. These information sets in turn could be used to stimulate experts in climate change, adaptation, and resilience to develop concrete estimates of potential future events. Likewise, the process of contingency planning would also require that consequences of future events be identified, which could be fed back into the overall international process of developing resilience in potentially affected countries.

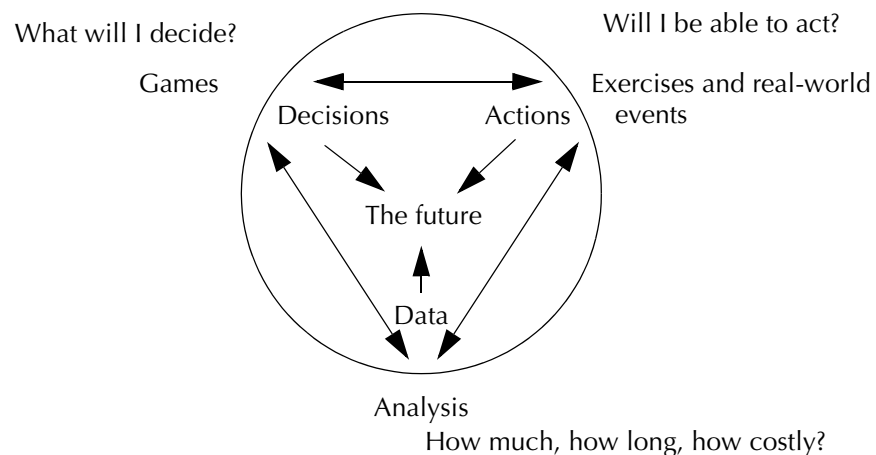
This planning process would, as it does in the military, feed into scenario-based events such as games or exercises. In these events, the consequences of future change would be explored and detailed sets of adaptation or resilience strategies identified.

## Games, exercises, and analysis

While the planning process can be used to anticipate and manage risk, in order to actually understand the implications of future events you need to understand the event's impact on decisions, capabilities, and process. The way the military develops this understanding is through gaming, exercises (and real-world events), and analyses [107–108].

As illustrated in figure 15, gaming provides information about decisions; exercises (and real-world events) provide information about your ability to respond; and analysis allows you to quantitatively explore a wider range of possible events and outcomes than either games or exercises.

Figure 15. Games, exercises, and analysis [108]



This process starts with the decisions you might make, then examines whether you have the capabilities to act on the decisions, and then uses analysis to quantify the problem and examine a wider range of possible solutions. Of course games, exercises, and analysis each work to inform the other, with games directing both analysis and exercises toward specific issues and decisions, and exercises and analysis feeding data back into games.

This process seems particularly well suited to understanding the problem of climate change as we have outlined it in this paper. Because committing military forces (and indeed almost any action by the US government) is motivated by political policy and foreign policy considerations, it will be important to understand how decision-makers might react to different climate scenarios. Games, in turn, require that the scientific and other data be “made real” in concrete terms that can be examined operationally. “The number of storms will increase” is insufficient to drive a game designed to explore the trade-offs between US resource commitment to domestic and international disasters. Instead, it will be important to identify as closely as possible the actual increases and the effect that these increases might have in terms of disaster response.

For climate change, real-world data can replace exercises as a source for information about capability and capacity to act. Given the considerable amount of data available on a wide range of real-world relief and aid operations, it should be possible to extract capabilities requirements for a variety of missions. Shortfalls can also be identified.

The data from real-world events can then be incorporated into analysis of potential futures. Analysis can be further shaped by insight into the possible policy decisions derived from gaming. This analysis could be used to estimate the quantity and nature of potential response capabilities.

This is essentially the planning and resourcing process used by the military in developing plans and capabilities for unknown contingencies. Given that we currently do not know how policy-makers will react to climate-change-induced disasters, and in some cases we may not fully understand the extent and nature of future disasters, these techniques may be an important tool in identifying risks and developing new processes and capabilities.

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## Conclusions

In this paper we have discussed two broad challenges that will face the US military, as well as other militaries, if global climate change increases the number of emergency events worldwide. The first challenge is that the number of missions that the military currently responds to will increase under climate change. These missions will evolve and increase, potentially stressing the military's capabilities to respond. At the same time, climate change will introduce a number of unknowns into the overall problem of emergency response, and these emerging missions may change the rationale for deploying military forces. We will discuss each of these challenges in turn.

## Evolving missions

The US military responds to a number of disasters each year without the impact of global climate change. One key question is how these responses will change in the future. Will they become more frequent? How will the political and social environment where these missions are executed change? And what will be the implications for military forces that are asked to respond?

It is not possible to use current climate change projections to predict precisely how many new emergency events will occur. Even if we could make those projections, the number of those events where military forces might be committed is a political policy decision which will depend on the international and domestic political strategy of the United States at the time.

What we can do, however, is say that current climate projections have the number of rapid-onset disasters increasing due to global climate change. These increases will be in addition to the normal cyclic variation that occurs in the climate. Both effects, change due to warming and normal cyclic effects, could work together to increase the

number of events that military forces traditionally have responded to in the past, such as higher category tropical storms.

At the same time, climate change is projected to increase the number of events, such as drought, that will place additional stress on already marginal economies. This increase in stress from climate change, along with other stressors such as population growth and factional conflict, may increase the overall instability in already marginal countries.

This increase in the number of rapid-onset disasters, combined with an increase in instability, could cause the US military forces to face additional requirements for both disaster and humanitarian response, as well as the need to respond in more situations where there is a security threat. The existence of instability could also force non-governmental and US government aid organizations to rely on United Nations and coalition military forces more frequently for security of aid delivery.

With both rapid- and slow-onset disasters occurring in an increasing number of unstable security environments, pressure for military involvement may increase. If the United States and the broader international community value stability, there may be an increase in the number of operations involving military forces. While increasing the capability of civilian organizations may provide substitutes for most military logistics and communications capabilities, there is currently no civilian substitute for the military's ability to conduct large-scale combat operations. This combination of conditions—the unique nature of combat capabilities, the potential for greater instability, and the desire to maintain a stable global environment—suggests that demands on the military may increase. If rapid-onset disasters are also seen as potentially destabilizing marginal states, this will increase pressure on military forces to provide security for response operations.

These increased pressures, in terms of both instability and the number of potential emergency events requiring response, will increase stress on military forces if they are required to respond. Depending on the number of responses needed, the demand for military forces to conduct low-intensity security operations in support of

disaster response will cause more units to be drawn away from their traditional training and deployment cycles. This will result in decreased readiness, increased force structure, or fewer missions being executed. If United Nations or coalition forces are involved in addition to or instead of US forces, they will ultimately face the same trade-offs as their commitments increase.

US government and international aid organizations are evolving the logistics and communications that will enable them to provide for humanitarian response in highly disrupted environments. However, it is unlikely that civilian organizations will evolve the unique capabilities to provide offensive and defensive security operations that military forces can provide. This tie—between the military’s unique role as a security force, and the increase in both disasters and instability—may result in an increased demand for military services no matter how robust the civilian capability becomes.

## **New missions**

In addition to the evolution of current missions, we identified two categories of missions that the US military currently does not respond to, but might have to begin responding to under climate change. We refer to these as either “emerging missions” or “revolutionary missions.”

### **Emerging missions**

Our primary example of an emerging mission is fire. The US military currently does not conduct large-scale deployments internationally in support of fire fighting (though the Guard does conduct extensive support for domestic fire fighting). If, as some models and studies predict, fire increases in some regions as a result of climate change, fire fighting may become more important as a disaster response mission for the military. This may require adapting some of the experience of Guard forces to regular forces, or developing an expeditionary fire fighting capability under the Guard.

While fire may become a new mission climate change may also bring forward any number of other missions that are currently not

commonly conducted. Identifying and preparing for these missions may become important when considering future force structure and mission sets.

## **Revolutionary missions**

In addition to new missions emerging, the motivation for deploying military forces may change as well. Fire fighting, for example, could be tasked to the military because it is an emergency—or it could be tasked because the fire’s carbon emissions might increase warming. As warming begins to affect social and economic activity the pressure for global decreases in carbon emissions may move from an environmental to a national security issue. Once the issue is identified clearly as a national security issue, military force becomes a viable tool for responding to various emitters.

## **Recommendations**

Based on our analysis, we recommend the following specific actions:

- Develop a database or summary site where specific results regarding the expected change in number, frequency, intensity, duration, or timing of future emergency events can be tracked. While current models do not provide sufficient detail for exact predictions, we found many instances in which available data predicted relative increases in these values under climate change. Without such values it becomes difficult to make predictions regarding future requirements.
- Develop and conduct games and simulations with key national officials and military commanders to better understand how the rationale for deploying and using forces will change under climate change. In addition, a broader effort to determine how the overall national security calculus will change could be undertaken through gaming techniques. Individuals familiar with the various pressures involved in formulating national security policy could be asked to respond to scenarios in which climate change had both affected national and international stability and increased the number of potential emergency

events. These games could identify trade-offs and key policy issues before they manifest in the real world.

- Develop a process for identifying and planning for emerging or revolutionary threats that may occur due to climate change. While not all—and perhaps not any—of these threats may actually happen, it could be important to understand what the response process would be, what the response might cost, and whether existing capabilities would be sufficient to meet the challenge. The military planning and simulation establishment has existing capabilities to facilitate this process, as it routinely plans for the unexpected or unanticipated national security event.
- Use the joint planning process, along with an analysis process involving gaming, real-world data, and analysis, to build a concrete planning environment for the potential futures that might occur due to climate change. This means developing an iterative strategy using games, real-world events or exercises, and analyses to understand the implications of climate change. Gaming can be used to require concrete decisions about different futures from policy makers. Real-world data and experience can be used to evaluate how actions and processes will really work. And analysis will help decision-makers understand the quantitative and scientific basis for decisions about future risk. The combination of all these techniques, as currently used by the military, allows for a decision-making and planning process that minimizes possible “surprises” or unanticipated and unplanned-for events.

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## List of figures

Figure 1. Relationship between climate effects and US HA/DR response . . . . .	11
Figure 2. How climate pressures can result in increased responses . . . . .	33
Figure 3. State Fragility Index: 2008 [70]. . . . .	38
Figure 4. Countries most at risk from climate change (as assessed by IDA [71]) . . . . .	39
Figure 5. Projected 2080 population increase [76]. . . . .	42
Figure 6. Global response framework illustrating the relative number of events responded to by various national, international, and United States organizations. . . . .	49
Figure 7. Disaster type by level of effort. . . . .	57
Figure 8. Level of effort according to disaster type. . . . .	58
Figure 9. Tropical storm responses according to level of effort (categories 1-9) and severity of the storm (Saffir-Simpson scale 1-5) . . . . .	60
Figure 10. Responses by service and level of effort . . . . .	61
Figure 11. Response by region and service . . . . .	62
Figure 12. OFDA-declared disasters and humanitarian responses, 1970 through 2008 (by fiscal year) [89–90] . . . . .	64

Figure 13. Ratio (as a percentage) of the number of disasters or humanitarian emergencies involving US military forces to the number of OFDA-declared disasters, by fiscal year . . . . .	65
Figure 14. Ratio (as a percentage) of military disaster and humanitarian responses to OFDA-declared disasters, by US Presidential administration . . . . .	66
Figure 15. Games, exercises, and analysis [108] . . . . .	78

# List of tables

Table 1.	Countries Most Affected by Drought, Flood and Storm [71] . . . . .	40
Table 2.	Number of responses by type . . . . .	53
Table 4.	Number of events in each level-of-effort category . . . . .	56
Table 3.	Framework coding for the nine levels of effort, accounting for both assets and duration of the event . . . . .	56

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